SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1920.

GENERAL PHYSICS.

482. *Baroscope for Explosion Waves.* **D. C. Miller.** (Phys. Rev. 14. pp. 450–451, Nov., 1919. Abstract of paper read before the Am. Phys. Soc., April, 1919.)—The device may be described as a combination of a telephone diaphragm and a spherometer to detect the motion of the centre of the diaphragm when an explosion wave reaches it. The position of the spherometer screen for contact is ascertained by its closing an electric circuit. A further paper with details is promised. E. H. B.

483. *Apparatus for Construction of Ellipses.* **Kaiser.** (Zeits. Instrumentenk. 39. pp. 333–337, Nov., 1919.)—The action of the apparatus described is based ultimately on the well-known property of the ellipse that the coordinates of any point on the curve are given by $x = a \cos \varphi$, $y = a \sin \varphi$, where φ is the eccentric angle. The principle of the construction of the apparatus is as follows: A circle has two diameters, O_1O_1, O_2O_2 at right angles. Arms A_1A_1, B_2B_2, capable of rotation in the plane of the circle, are pivoted at the 4 points $O_1O_1O_2O_2$. These arms are connected by a rigid square framework, which is pivoted at its corners to points situated about at the centres of the rotating arms $A_1A_1B_2B_2$, which are thus caused to be always parallel to one another. The ends of a bar S_1 are pivoted to points on the arms A_1A_1, and the distance of these pivots from the points O_1O_1 is made equal to the semi-major axis a of the ellipse to be drawn. A similar bar S_2 is pivoted to the arms B_2B_2, the pivot distance from the points O_2O_2 being adjusted to the length of the semi-minor axis b of the ellipse. The bars S_1S_2 are, of course, equal in length to the diameter of the circle. A pencil carrier in the form of a tubular cross is situated where the bars S_1S_2 cross one another, and is a sliding fit on the bars. With this arrangement, when the framework is rotated, the pencil at the intersection of S_1 and S_2 will describe an ellipse of semi-axes a and b. A drawing of the actual apparatus is given, together with a detailed description. A. W.

484. *The Measurement of Tapes and Wires at the Reichsanstalt.* **P. A. Thomas.** (Zeits. Instrumentenk. 39. pp. 321–332, Nov., 1919.) —A description of the 30-m. measuring track used for the most accurate measurement of invar and other tapes and wires. A description is given of the sledge carrying the travelling microscope and of the procedure involved in a complete test of length. There are seven illustrations of the details of the apparatus. P. E. S.

485. *Adjustment of Observations.* **N. Campbell.** (Phil. Mag. 39. pp. 177–194, Feb., 1920.)—Describes a method, which is simpler and quicker than the method of least squares, for finding the normal equations in the determination of the constants of a physical equation from a large number of observations. This method consists in the grouping of the observational equations in equal numbers, the number of groups being equal to the number of normal equations required, *i.e.*, the number of constants to be determined. These groups are then added, and the equations of sums thus obtained are solved in the ordinary way. The method is justified on theoretical grounds, and examples are given of its application in practical cases. In a further paper the validity of the new method (termed the method of "zero sums") will be further discussed. J. W. T. W.

486. *Ocean-Current Measurement by Pitot Tube.* **Y. Delage.** (Comptes Rendus, 170. pp. 213–218, Jan. 26, 1920.)—The use of the Pitot tube for the measurement of current velocities in open sea suffers from the difficulties of finding the true head on account of the variations of water-level. Moreover, uncertain error in estimations is introduced owing to the fact that the mean head is proportional to the mean of the velocities squared. If, however, the upper end of the Pitot tube were maintained exactly at water-level, the quantity of water spilled over from the tube in unit time would be directly proportional to the velocity. An apparatus is described and figured with which the upper end of the tube can be kept at water-level, the effect of surface waves eliminated, and the overflow from the tube collected. W. A. R.

487. *Researches at High Pressures and Temperatures.* **C. Parsons.** (Engineering, 119. pp. 150–151, Jan. 30, 1920. Abstract of Discourse delivered at the Roy. Inst., Jan. 23, 1920.)—When we press two knife blades together or use a hand Brinell hardness tester, we apply pressures of 300 tons and more per sq. in., whilst the gas pressures in guns rarely exceed 20 tons per sq. in., and 8 tons per sq. in. is about the equivalent of 1000 atmos. According to Bridgman a sealed glass tube may bear 24,000 atmos. for three hours, which might correspond to the pressure in the interior of the earth at 56 miles depth. The deepest existing shaft having a depth of 6400 ft. only, the lecturer suggested that a shaft should be sunk to a depth of 12 miles and kept cool and supplied with oxygen by sending liquid air down in vacuum-jacketed pipes. The pressure at the centre of the earth was roughly estimated at 6000 tons per sq. in., and such pressures as well as temperatures of 17,700° C. had momentarily been approached in his experiments on the formation of diamonds [Abs. 487 (1919)], which he reviewed from that point of view. H. B.

488. *Elastic Limit of a Ductile Metal.* **B. P. Haigh.** (Engineering, 119. pp. 158–160, Jan. 30, 1920.)—Proposes a new system for the determination of the elastic limit of a ductile metal when subjected to complex stresses. In this it is supposed that the criterion is the energy absorbed by the material in virtue of its elastic strain, and it is shown that the results obtained on this hypothesis agree with those experimentally established better than do the calculations based on either the Rankine, de Saint-Venant, or Guest hypotheses. J. W. T. W.

489. *Buckling of Deep Beams.* **J. Prescott** and **H. Carrington.** (Phil. Mag. 39. pp. 194–223, Feb., 1920.)—In a previous paper [see Abs. 5 (1919)] it was shown that a deep beam may fail by a sort of torsional instability, and the load at which this occurs was calculated for beams under uniform loads or certain special loadings and methods of support. In the present paper the method is generalised and the results extended. The appendix gives an experimental verification of some of the formulæ, and in most cases the results obtained agree very closely with those calculated. J. W. T. W.

490. *Stress Distribution in Engineering Materials.* (British Assoc. Report. Engineering, 109. pp. 25–27, Jan. 2, and pp. 64–66, Jan. 9, 1920.)—This report is divided into six sections. (1) *Strength of Tubular Struts,* by **A. Robertson.**—Experimental results lead to the following conclusions for tubes of mild steel in which the elastic limit and yield are almost identical: (*a*) for tubes in which thickness/radius is greater than 0·006 yield precedes collapse by wrinkling; (*b*) for tubes in which t/R is greater than 0·44, complete collapse occurs at higher stresses than the yield, whilst thinner tubes sustain the yield stress and collapse immediately by the walls caving in. The yield stress in compression is the upper limit of strength for a strut of ductile material, so that the strength of a tubular strut in which $t/\mathrm{R} > 0{\cdot}006$ is the same as that of a solid strut having the same L/K and the same yield stress, provided the end connections are satisfactory.

(2) *Stresses in Aeroplane Wing Frameworks,* by **L. N. G. Filon.**—This is an account of experiments undertaken to test a theory of Booth, Bolas, and Berry for calculating the stresses in the frameworks carrying aeroplane wings. This theory contains an extension of Clapeyron's theorem of Three Moments so as to include the effects of bending moment due to end-thrust. This modified theorem, together with the thrusts obtained by the ordinary theory of pin-jointed frameworks, enables the bending moment and shear at each cross-section to be calculated, and hence the max. tension and pressure in the spar. A paper by Cowley and Levy [see Abs. 890 (1918)] gives an extension of the method to the case where the nodes are not all in one straight line.

(3) *The principle of Dynamic Similarity for Deformable Elastic Structures,* by **L. N. G. Filon.**—Investigates the relations which have to be satisfied by the elastic constants of, and the stresses applied to, a mechanical model of any structure made accurately to scale, but of different material. Xylonite is a much more yielding material than wood, so that if the full-size spar is of wood, loads on a xylonite model will usually be well within the safety limit even when the corresponding loads on the full-size wooden member exceed the safety limit.

(4) *The Soap-film Method of Stress Determination,* by **A. A. Griffiths.**—This outlines the method described in a published paper [see Abs. 221 (1918)].

(5) *Eccentric Loading in Tension and Compression Tests,* by **W. A. Scoble.**—Describes experiments on eccentric loading and the varia-

tion of strain across the section of a test-piece. This is often considerable, but it is not possible to draw many general conclusions from the data obtained.

(6) *Effect of Alterations of Tensile Stress at Low Frequencies on the Elastic Properties of Mild Steel*, by **A. R. Fulton.**—This describes experiments in which there was a variation of tensile stress as distinct from a variation of stress from tension to compression. It was found that after ordinary yield is exceeded and a permanent elongation has taken place, the limits of the proportionality of stress and strain are raised. The extent of this elongation for any max. stress depends on whether the stress has been applied in one stage, or with a sufficient number of repetitions at each of several stages. The range of stress over which this proportionality is maintained is limited: once established it is independent of the number of cyclical repetitions to which it is subjected. The range of stress may be again varied by further elongation, but to this there is a limit. Failure under repetition of tensile stress occurs by the movement of the crystals relative to one another, consequent on the existing range of stress being exceeded, or during the transition period, when one range is being changed to another. Failure frequently originates by the range of stress, or even the max. static stress of the material, being exceeded in parts of a section, and is due to mechanical flaws in the material or to non-axial loading. J. W. T. W.

491. *The Effect of Work on Metals and Alloys.* **O. W. Ellis.** (Inst. of Metals, J. 21. pp. 319–333, 1919. Engineering, 108. pp. 290–292, Aug. 29, 1919.)—Contains a summary of the generally accepted facts as to the effect of work on the physical properties of metals and alloys. From the work of certain investigators, evidence has been obtained of the existence of points of inversion in graphs connecting the percentage reduction by work, and the mechanical properties of steel, brass, and copper. Results are given showing the variations in mechanical properties of α-β brass containing Cu 61, Zn 39 %, as a result of reducing the thickness by rolling. The Brinell number-reduction graph of this series shows an inversion at about 50 % reduction. Photomicrographs of the brass show little evidence of the effect of work up to 36 % reduction, but with 50 % reduction distinct signs of the effect of work are visible. The author suggests that Hanson's law for strained metals and solid solutions—namely, "For every degree of deformation there is a critical crystallisation temperature at which crystal growth is extremely rapid, and the size of the crystals produced by this growth is the greater the smaller the amount of deformation preceding such annealing," may be extended to meet the case of the 61 : 39 brass, and also that the converse of the above law is also true—that for every temperature there is a critical degree or range of deformation over which recrystallisation is extremely rapid. Further evidence in favour of the above is given in results with 70 : 30 brass and 80 : 20 cupro-nickel, showing the relation found to exist between percentage reduction in the thickness of rolled strip and the power absorbed in the reduction of the strip. It is also suggested that the critical degree of deformation commences at a lower stage, the less the initial thickness of the material undergoing deformation. C. O. B.

492. *Analysis of Statically Indeterminate Structures by the Slope-deflection Method.* **W. M. Wilson, F. E. Richart,** and **C. Weiss.**

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(Univ. of Illinois Eng. Experiment Station, Bull. No. 108. [214 pp.], Nov., 1918.)—Deals very fully with the advantages of the slope-deflection method for the analysis of the stresses in frames composed of rectangular elements. Part I shows the derivation of fundamental equations, Part II giving methods and equations for use in determining moments, stresses, and deflections for a variety of typical structures. L. H. W.

493. *Laws of Relative Motion and Flight of Projectiles.* **F. Neeson.** (Deutsch. Phys. Gesell., Verh. 21. pp. 589–593, Sept. 30, 1919.)—In dealing with the effect of wind on the flight of projectiles, the air-resistance is usually taken to be the same as would be experienced by a projectile travelling through a stationary atmosphere with a velocity equal to the relative velocity of shot to air. But though the air-resistance depends on the relative velocity, the discussion of the subject given in the present paper shows that the air-resistance (1) to a shot moving through still air with a velocity v is not necessarily the same as (2) when the air is in motion and the velocity of the shot relative to the air has the same value v. The simple case is considered where the direction of the wind is opposed to that of the shot, and the air particles are considered as small elastic spheres, the shot having a conical nose of semi-angle a. The laws of elastic impact then show that there is a decided difference between cases (1) and (2) above. A further difficulty is introduced by the rotation of the shot, the friction due to this rotation not being a pure function of the velocity of the shot relative to the air. The effect of the situation of the axis of the shot relative to the line of flight has also to be considered. A. W.

494. *Distribution of Air Pressure around the Funnel of a Vessel at Sea.* **A. P. Thurston.** (Engineering, 119. pp. 134–135, Jan. 30, 1920.)—It has been found [see Abs. 908B (1914)] that in the case of small circular rods in a stream of air, the compression region extends over an arc of only 78°, the remaining four-fifths of the circumference being in suction. This suction actually introduces a component force, opposite to the direction of the wind, on the outer sides of the half of the rod facing the wind. The present paper describes experiments undertaken on the funnel of the s.s. *Patuca*, and the results obtained confirm those found for the small rods. The funnel was not circular, but elliptical in section. J. W. T. W.

495. *Discussion on Lubrication.* (Phys. Soc., Proc. 32. pp. 1s–18s; Disc. and Corres. 19s–34s, Feb., 1920. Engineering, 108. p. 788, Dec. 12, 1919. Abstract.)—**R. M. Deeley.**—Vegetable and animal lubricants are esters, formed by the union of alcohol radicals with fatty acid radicals. Mineral lubricants are essentially hydrocarbons. According to B. Tower's experience and O. Reynold's theory, any viscous liquid may act as a lubricant under conditions in which a film is formed. Otherwise the lubricant must possess the quality of "oiliness," the nature of which has not yet been satisfactorily defined, but probably depends, as W. B. Hardy has suggested [Abs. 1142 (1919)], on adsorption of the lubricant by one or other of the metallic surfaces, in which case Hardy would regard lubrication as a problem of colloid physics. The author described his frictional testing machine, experiments with which showed the static friction to vary both with the lubricant and the metals in contact.

"Oiliness," he considered, would appear to be an effect produced by the lubricant upon the metallic surfaces with which it is in contact, rather than the result of any special physical property of the lubricant. Dunstan and Thole [Inst. Petroleum Technologists, Jour. 4. pp. 191–228, 1918] concluded that all good lubricating oils contain unsaturated molecules, and it would appear that they enter into a firm physico-chemical union with the metallic surfaces, so forming a friction surface which is a compound of oil and metal. It would seem to be more than a molecule in thickness, due either to the oil penetrating some little distance into the metal, and altering its physical properties, or, as the result of abrasion, forming a paste of metal plus oil between surfaces covered by oil layers one molecule thick. If this substance, oil plus metal, should be torn off the surface, fresh oil combines with the freshly exposed metal, so that touching and abrasion of the metal is prevented. But with heavy loads, the frictional heating may destroy the lubricant, when the surfaces seize and abrade each other.

H. M. Martin.—The theory of O. Reynolds, as supplemented by Sommerfeld, and notably by A. G. M. Michell, in the author's opinion, completes lubrication theory on the physical side. He endorses Reynolds' view, that even in imperfect lubrication a separating film prevents contact —certainly in the case of fluid lubricants; and in solid lubricants some fluid film may be formed. He believed that, as Faust has shown that ether and cognate liquids increase enormously in viscosity at high pressures, the same might apply to lubricating oils, as was confirmed by experiments at the National Physical Laboratory suggested by himself. But the increase being less with vegetable and animal than with mineral oils, this would not account for "oiliness." An experiment of Rayleigh's [Abs. 329 (1918)] suggested that a very thin layer of lubricant could withstand without slip a higher rate of shear than a thicker one, and experiments showing that actual flow of gear teeth may occur in service prove that the shear stress in the film may be exceedingly high. The author therefore thinks that in badly lubricated bearings, thoroughly run in, the load is concentrated on a narrow band of the brass, and not on isolated points, as he had formerly agreed with Reynolds in believing.

H. S. Allen.—I. Langmuir's experiments on surface films [Abs. 1230, (1917)] showed that animal and vegetable oils do, and mineral oils do not, spread on water, which he attributed to the presence of active molecules in the former and not in the latter. The presence of such molecules in a lubricant may well be a determining cause of adsorption by one or both the bearing surfaces, giving rise to a film of lubricant.

T. E. Stanton.—J. H. Hyde's experiments with Lanchester's worm-gear testing machine have shown that 97 % efficiency is obtainable with pressures between the teeth of the order of 5 tons per sq. in., and that the efficiency was practically unchanged by temperature change from 25° C. to 45° C., so that the viscosity could have had no appreciable effect.

L. Archbutt.—The anti-friction alloys illustrate the importance of the bearing surface. Goodman found, many years ago, that traces of foreign metals increased the friction when of smaller atomic volume than the alloy, and diminished it when of greater atomic volume. In Langmuir's theory the molecules, the oil, and the surface are held together by residual or secondary valence. Hence the importance of Southcombe's discovery of the importance of the free fatty acid in lubricating oils in the case of

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solid friction. Their presence in very small quantities improves the lubricating value of mineral oils as much as a much larger quantity of fatty oils, which might be inadmissible, *e.g.*, in the presence of moisture.

W. B. Hardy.—In the friction of Bi on Bi a single hydroxyl group introduced into a molecule increases its lubricating value, but adding a second or third group decreases it. The worst lubricants are simple symmetrical compounds. He denies any virtue to non-saturation.

A. E. Berriman—A perfect plug gauge moves readily in a perfect ring gauge if the surfaces are lubricated and the motion is maintained, but will seize on the relative motion ceasing. This seems to favour Martin's theory, that the metal is not chemically affected, but that good lubricants adhere in ultimate films, rather than Deeley's theory, that a new solid compound is formed on the surface; because there has been no physical abrasion to remove the chemical compound, and the quality of the friction should not be dependent upon a state of motion. This dependence suggests a relation between oiliness and surface tension.

F. W. Lanchester.—Reynolds' theory is the truth, but not the whole truth, and might be called "The Theory of the Thick Oil Film in Lubrication." Even in an ordinary journal, until well bedded, oiliness is important. A reasonably complete lubrication theory might very possibly lead to lubricants which will enable machines to be worked at really high temperatures. But if investigations lead only to the more economic and appropriate use of known lubricants their financial value will be incalculable.

R. S. Willows.—The theory proposed by Thomson [Abs. 1910 (1914)] and Langmuir, from different standpoints, goes some way towards a solution, and has much evidence in its favour when oiliness and adsorption are considered in electrical terms, and in relation to such other effects of the existence of electrical doublets surrounded by a strong electrical field, as surface tension and viscosity. The two main characters of a good lubricant—adhesion to the solid and high viscosity—can be accounted for, and such friction as there is will be between the adsorbed layer and those liquid layers near it. G. W. DE T.

496. *Stream Motions in Fluids caused by Rotating Linear Bodies.* **P. Metzner.** (Phys. Zeits. 20. pp. 536–542, Dec. 1, 1919.)—The author's theoretical treatment is followed by an experimental part, which, however, requires to be studied in conjunction with the illustrations given in the original of the flow effects observed. L. H. W.

497. *Properties of Metals.* II. **F. Haber.** (Preuss. Akad. Wiss. Berlin, Ber. 51. pp. 990–1007, 1919.)—A theoretical paper dealing with the alkali metals, and with Ag, Cu, and Tl. Theories due to Born and Debye are discussed. [See Abs. 1268 (1919).] A. W.

498. *Work of the Bureau of Standards in* 1918–19. **S. W. Stratton.** (U.S. Department of Commerce, Misc. Publ. No. 40. [293 pp.], Washington, 1919.)—The Director of the Bureau gives a review of the work for the year ending June 30, 1919. Brief accounts are given of practically all of the special researches and lines of testing completed or under way. The Report gives in a handy form a comprehensive view of the multifarious activities of the Bureau. L. H. W.

499. *Surface Energy of Crystals and its Influence on Crystalline Form.* **M. Born** and **O. Stern.** (Preuss. Akad. Wiss. Berlin, Ber. 48. pp. 901–913, 1919.)—The classical theory of capillary phenomena of Laplace and Gauss explains these by the assumption of cohesion forces, *i.e.*, attractive forces between the fluid particles dependent only on the distance and acting in the line of union. The capillarity constants may be determined by integration processes from the laws of these cohesion forces. This circumstance has been mainly used for deducing conclusions as to the dimensional order of the cohesion forces from the known dimensions of the capillarity constants. The converse method could not be applied so long as data concerning the nature of atoms and molecules and the forces between them remained so scanty. Recently, however, the nature of the cohesion forces has been explained for certain classes of substances [see Abs. 528 (1919) and Abs. 14 (1920)], and their electrical origin established. These results, however, concern crystals and not liquids, although phenomena have been observed analogous to the capillarity of liquids, in that they can be traced to surface energy and surface tension.

In the present paper, the theory of surface energy for crystals is broadly developed. There are principally two directions in which surface tension appears in crystal phenomena, namely: (1) By effecting a change in vapour pressure and solubility: this influence can only be determined by an absolute dimensional measurement; (2) by its influence upon crystal form when separation takes place from vapour or solvent. This has been thermodynamically investigated by Gibbs and Curie, who state that a crystal is only in thermodynamic equilibrium with its vapour or solution when it possesses that form whereby the free energy of its surface has a smaller value than in any other form of equal volume. Section 1 of the paper investigates the cohesion of the alkali halogen crystals. Section 2 defines the capillarity constant for a crystal face. Section 3 calculates the capillarity constant for the cube face of the regular alkali halogen salts. Section 4 calculates this constant for other faces of these regular halides. Section 5 investigates the energy at edges and corners. [The paper is mathematical throughout.] H. H. Ho.

500. *Langmuir's Theory of Atoms.* **S. C. Bradford.** (Nature, 105. p. 41, March 11, 1920.)—The author observes that, in view of the extraordinary power of Langmuir's theory, it is important to inquire whether his argument from the fixity of direction of the valency forces necessarily holds. A consideration of model atoms, on the Langmuir theory, of Ne, F, and O, indicates the possibility of revolution of the static groups of electrons, which would add to the stability of the molecules formed by their combination and increase the directional steadiness of the valency forces. In this manner it may be possible to reconcile Langmuir's theory with that of Bohr. G. W. de T.

501. *Dynamics of Spacial Atomic Structure.* **A. Landé.** (Deutsch. Phys. Gesell., Verh. 21. pp. 644–652, Oct. 30, 1919.)—The equations of motion for systems of 4 and 8 electrons, whose orbits exhibit the symmetry of 24 equi-valued points on the regular tetrahedron and 48 equi-valued points on the cube respectively, have previously been obtained by the author [see Abs. 684 (1919)]. In the present paper such orbits are explicitly evaluated for special cases approximating to 8 electrons in

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cubic union about the nucleus $+ Ze$. For 8 electrons in cubic union and 4 electrons in tetrahedral union, the mechanically possible orbits in the limiting case of small nucleus charges have the form of small circles. The paper contains the theoretical quanta values for the radius and energy of cubic and tetrahedral atoms. H. H. Ho.

502. *The Structure of Atomic Nuclei.* **E. Gehrcke.** (Deutsch. Phys. Gesell., Verh. 21. pp. 779–784, Dec. 30, 1919.)—Up to the present the structure of the nuclei of atoms has only been examined in the simplest of chemical elements—namely, the hydrogen atom, hydrogen molecule, and the helium atom. On the basis of Bohr's theory, with some slight additions, the author now extends the analysis to the elements lithium, beryllium, boron, carbon, and nitrogen. Illustrative diagrams are given of the suggested nucleus structure of these atoms. It is interesting to observe that the nitrogen atom has an innermost H_2^+ nucleus ion, and 3 helium ions (α-particles) in a surrounding ring; this structure is, of course, that proposed by Rutherford. A. B. W.

503. *Atomic Nuclei and α-Rays.* **H. T. Wolff.** (Ann. d. Physik, 60. 8. pp. 685–700, Dec. 19, 1919.)—This paper deals with the question mathematically. The following are the principal points examined:—
(1) The number and arrangement of positive particles in the nucleus;
(2) The forces acting on these particles; the orbits of the positive particles;
(3) The nucleus electrons and β-rays.

As a result of his analysis, the author considers the nucleus to have the form of a circular disc, made up of concentric rings. Positively-charged H- and He-particles describes circular orbits around the midpoint of the atom as centre. Around each positive charge revolve the negative electrons. A potential formula is given, showing how the electric potential varies between the rings of positive electrons inside the nucleus. A. B. W.

504. *Adiabatic Method for the Quantelation of Disturbed Electronic Systems.* **A. Landé.** (Deutsch. Phys. Gesell., Verh. 21. pp. 578–584, Sept. 30, 1919.)—The electronic orbits in atoms are in many cases accessible to theoretical treatment in that they may be regarded as deviations from known simple orbits, the number of mechanically possible disturbed orbits being limited by quanta conditions. The latter have been given by Epstein, Schwarzschild, and Burgers for very general cases of orbits. These methods, however, possess the property of regarding the energy of the disturbed system as a whole, while in many cases, especially in spectral problems, the energy has to be differentiated, *e.g.*, in an atom consisting of several electrons the change of energy through disturbance may be small compared with the total energy, but considerable against the electronic energy at the extreme end of the spectrum. The author now introduces a method of quantelation which applies directly to the required small energy disturbances, and which is based on the Ehrenfest adiabatic hypothesis. The principle of the method is set out in Section 1. As an example a number of electronic rings are investigated in Section 2, whose configuration may be denoted by a coordinate number a, so that the potential energy of the electrons of the kth ring towards one another and towards the nucleus only depends on a_k. Section 3 treats the example of two coplanar rings. [The paper is mathematical throughout.] H. H. Ho.

505. *Possible Ether Structure.* **O. J. Lodge.** (Phil. Mag. 39. pp. 170–174, Feb., 1920.)—Silberstein's complication of introducing compressibility [see next Abs.], and, moreover, an enormous gravitational compression, in order to evade rotationality in a hypothetical ether dragged by moving masses, does not commend itself. An incompressible non-viscous ether is more simple, and particularly in reference to aberration theory, which is unduly complicated in the absence of velocity potential. Moreover, such imperfections as frictional and thermal effects, accompanied by dissipation of energy, are appropriate to a secondary cosmic ingredient, like matter, but not to the fundamental substance itself. If we attribute all locomotion to matter, including electric charges, and all elasticity to ether, regarding the latter as the uniting and potentially strained medium responsible for every force which holds atoms together, we shall be on sound and simple lines. This is not to deny that potential energy may be susceptible of ultimate kinetic explanation, in terms of the postulated fine-grained vorticity. How the singular points characteristic of electric change are constituted remains to be discovered, and the author is confident that when the electric structure is made out, the small second-order tension responsible for gravitation will be accounted for. *The fact that a luminous disturbance simulates the fundamental properties of matter is giving us a broad hint.* A wave-front is an evanescent kind of matter—a sort of attempt of an accelerated electron to reproduce itself: the question is how such a peculiarity can be made permanent and its violent locomotion checked. We must find out how to disturb the ether so that the modification shall remain concentrated, instead of instantly dispersing itself with the speed of light. The electric and magnetic components must be separated, the one kept and the other annulled. The transmission of transverse vibrations shows structure—incomparably fine grained—in the ether. To explain gravitational and other facts, the formation of an electron must involve that of radial stress around it, accompanied by a reduction of circulatory energy in its vicinity; not necessarily causing change of density, since electrostatic facts, notably the Cavendish experiment, show the ether to be practically—probably actually—incompressible, but affecting its elastic or dielectric constant in such manner as to modify the velocity of light in the neighbourhood. An electron might, in fact, be a small region in which intrinsic circulation has ceased, so that it possessed inertia only. The tension in reduction of pressure set up in the neighbourhood of such a centre of force could explain gravitational attraction, and a change of rigidity would also suffice to explain the very minute reduction in the velocity of light. The refractive index needed at any point is $1 + 2\gamma M/rc^2$, or $1 + u^2/c^2$, where u is the velocity of free fall from infinity, which is just what the light has done. The dielectric constant would be modified so that $K/K_\infty = 1 + 4\gamma M/rc^2$, the second term being Einstein's deflection. It may be taken as representing the deficiency of ethereal circulation energy near a massive body, as compared with the unmodified value in free space. G. W. de T.

506. *The Stokes-Planck Ether.* **L. Silberstein.** (Phil. Mag. 39. pp. 161–170, Feb., 1920.)—The irrotationality of motion of the ether demanded by the phenomena of aberration of light with the simultaneous absence of slip at the earth's surface, and the incompressibility of Stokes' theory, being irreconcilable, Planck suggested that the incompressibility should be discarded, and replaced by the assumption of a gravitative condensation (as, *e.g.*, of a perfect gas) in the neighbourhood of the earth and other gravitating masses. The author suggests that such condensation might be the origin of the recently observed bending of light rays passing near the sun's surface, as an alternative to the Einstein explanation. Assuming Boyle's law, the density ϱ and the pressure p of the ether near the earth's surface could be related by the equation $\varrho = \varrho_{\infty} e^{a\mathrm{M}/r}$, where ϱ_{∞} is the value of ϱ at infinity, M is the earth's mass in astronomical units, a is a constant, and r is the distance of any external point from the earth's centre. Then, if R is the earth's radius, and $\sigma \equiv a\mathrm{M/R}$, the maximum slip at the earth's surface will be $v = v_{\infty} \sigma^3/4\left\{e^{\sigma} - (1 + \sigma + \sigma^2/2)\right\}$, where v_{∞} is the velocity at infinity. The astronomical aberration, a first-order effect, would be accounted for within the limits of experimental error for $v = v_{\infty}/100$, say $\sigma = 10{\cdot}2$, or $s \equiv \varrho/\infty \doteqdot 27{,}000$. And this would reduce the Michelson-Morley, or other second-order effects, to 10^{-3} of their value, in accordance with the ordinary ether theory. Lorentz [Theory of Electrons, pp. 173–4] pointed out the unsatisfactory nature of Planck's hypothesis, "*combined, as it must be, with the hypothesis that the velocity of light is not in the least altered by it.*" But this objection is removed by the recent eclipse result. Adhering to Boyle's law, which, however, is by no means necessary, the value of σ will be approximately 31,000, and v/v_{∞} will be almost evanescent. But near an H atom, assumed a homogeneous sphere, or any atom, we should have $s \doteqdot 1 + 1{\cdot}7 \times 10^{-34}$, which is indistinguishable from unity, and the ratio v/v_{∞} will approximate closely to its limiting value 3/2, the maximum relative step for a sphere moving in an incompressible liquid. The author then generalises the condensation formula, replacing Boyle's law by *any* relation between p and ϱ. It is pointed out that we could not produce the possible longitudinal waves to a relevant extent, and if necessary in nature, they would merely alter slightly the propagation velocity from c to c', corresponding to a condensation change from s to s'. This could obviously be determined only from experience. Assuming the deflection of rays passing near the sun to be represented by Einstein's formula, it is found that the refractive index $n = c/c'$ at any distance $r > \mathrm{R}$ from the sun's centre will be determined by $n^2 = 1 + 4\mathrm{M}/c^2 r$, or, denoting the potential by Ω, and generalising to any distribution of gravitating matter, $n^2 = 1 + 4\Omega/c^2$, the relation between n and the velocity of propagation v will be determined by $c^2(n^2 - 1) = 4\int v^2 d \log s$. The bending of the rays round the more massive celestial bodies would be merely a by-product of the theory. In view of the small condensation around single atoms in corpuscles there would be no difficulty in developing a satisfactory electromagnetic theory of ponderable media. The theory would have the advantage of not predicting the absent gravitational shift of the spectrum lines, and it might react, in part at least, upon Einstein's 1905 relativity, depriving it of its indispensability in most cases, but by no means banishing it from the domain of physico-mathematical investigation. Finally, the just objections of advocates of the *physical* principle of causality against the fixed, homogeneous Fresnel-Lorentz ether would apply to Stokes' modified ether. For the latter would be no mere reference framework, illegitimately privileged, since the reference would be to assignable physical things—those most massive gigantic bodies which have the strongest grip upon that medium. G. W. DE T.

507. *Melting-Points and Atomic Numbers of Chemical Elements and Atomic Restoring Force.* **S. Ono.** (Phys. Math. Soc. Japan, Proc. 1. pp. 251–260, Sept., 1919.)—If an atomic vibration be assumed to be a simple oscillation, the force D maintaining it in continuous vibration will be $4\pi^2\gamma^2 m \times$ displacement, when γ is the frequency, and m the mass. D, here called the restoring force, is, according to Lindemann [Abs. 1389 (1910)], proportional to $T/V^{2/3}$, where T is the absolute temperature of the melting point, and V is the atomic volume. The existence of some approximate empirical relations between the melting-point and other physical constants of the chemical elements, considered separately in groups, is graphically represented and discussed here and in a former paper [Abs. 1334 (1919)], and taken, in combination with Lindemann's result, as a basis for suggesting that the restoring force of the atom is probably proportional to the atomic number, and that if the restoring force be assumed to vary inversely as the nth power of the mean atomic distance, n will, for most of the chemical elements, lie between 7 and 9. If this be so, the relation will be representable in the form $\gamma = 1/2\pi(\mathrm{BN}/md^n)^{1/2}$, where N is the atomic number, d the mean distance of the atoms, and B a constant characteristic of each group, probably related to the valency and crystalline form. G. W. de T.

508. *Derivation of Lorentz-Einstein Transformation.* **H. Jeffreys.** (Phil. Mag. 38. pp. 349–351, Sept., 1919.)—Given two systems of reference, S and S′, it follows from the assumption that c, the velocity of light, is constant, that $\dot{x}^2 + \dot{y}^2 + \dot{z}^2 = c^2$ implies $\dot{x}'^2 + \dot{y}'^2 + \dot{z}'^2 = c^2$. (1) Writing $icdt = du$, $icdt' = du'$, $dx^2 + dy^2 + dz^2 + du^2, = ds^2$, $dx'^2 + dy'^2 + dz'^2 + du'^2 = ds'^2$, (1) becomes $ds = 0$ implies $ds' = 0$. (2) Hence $ds' = kds$, where k may be any function of x, y, z, t. From this $ds' = ds$ (3) would follow if x', y', z', t' were linear functions of x, y, z, t (4); but there in no ground for this assumption. But the assumption that any object moving uniformly with regard to S is moving uniformly with regard to S′ (5), is warranted by the relativistic modification of Newton's first law, according to which $\dot{x}$, $\dot{y}$, $\dot{z}$, $\dot{x}'$, $\dot{y}'$, $\dot{z}'$ are constants for an isolated particle referred to axes in an isolated non-rotating body. Therefore, comparing *any* uniformly moving object with an isolated particle, whenever $\dot{x}$, etc., are constant, so are $\dot{x}'$, etc. If so, $\dot{s}$ and $\dot{s}'$ are constant, and then also dx/ds, dy/ds, dz/ds, du/ds, are constant, whence d^2x/ds^2, etc., are all zero. Conversely, if d^2x/ds^2 are all zero, so also are d^2x'/ds^2, etc. (6). Thus (5) is equivalent to (6). But (6) is equivalent to the proposition that if $\int ds$, taken along a path between two points in four-dimensional space, is unaltered by small variations in the path, $\int ds'$ is also unaltered. But $ds' = kds$, so that when $\int ds$ is stationary, so is $\int kds$, and hence it will follow that k is constant. To make $k = 1$, and $\therefore ds = ds'$, requires only a permissible change of units. Again, $dx'/ds' = dx'/dx \,.\, dx/ds'$, etc. And when dx/ds, etc., are constants, so are dx'/ds', etc., by (6). Hence dx'/dx, etc., are constants, and x' is a linear function of x, y, z, u. Similarly y', z', u' are linear. Postulates (3) and (4) being proved, the transformation can be obtained by Cunningham's method [Principle of Relativity, p. 49 (1914)]. G. W. de T.

509. *Generalised Relativity and Johnston's Calculus.* **J. Larmor.** (Roy. Soc., Proc. 96. pp. 334–363, Dec. 15, 1919.)—The author discusses Johnston's calculus [see Abs. 418 (1920)], and uses it in a very fundamental discussion of electromagnetic relativity, of which space prevents more than brief reference to salient points. He observes that a method of direct relativity can be said to assert itself only in so far as a hyperquaternion calculus can be framed, operating directly with hypervectors, such as Δ_1 and U, without any relation to a special unitary system of reference such as *ijk*, etc., and this symbolic calculus seems to constitute another direct help to hyperspacial synthesis. Failing such, there is only the indirect method, which cannot help using *ijk*, etc., but bases the relativity on the proposition that there is nothing to distinguish one such system from any other; a conclusion, in substance, that could we transcend the modes of representation of the physical world that are open to us, we should discover direct relativity. The method of Variations on Riemann's foundation has been a substantial feature in the continual effort so to transcend. Neither $x^2+y^2+z^2$ nor the corresponding Δ^2 can be invariant in a quaternary algebra *ijko*, except by breaking up into an algebra of space and one of time. In the Minkowski 4-space, electrodynamic relativity seems to be secured in free ether by sacrificing the permanent existence of electrons, material particles, and space itself as independent of time. World-lines, and in a later form only their intersections, survive. The material world vanishes that relativity may survive. It seems more practical to persist as far as possible with the Newtonian procedure in terms of matter and motion and, apart from the recent astronomical evidence, quite competent to secure, by slight deformation of material measuring systems, the observed relativity in relation to matter which is otherwise interpretable by merging time and space into one manifold. The author considers that Einstein's theory has come to stay in some form or other, and observes that its main implication, of instantaneous propagation of change in spacial constitution, can be avoided by including the varying space in a uniform space of higher dimensions, just as the deformation of a two-dimensional surface can be visualised as a whole in three-dimensional space. Gravitation phenomena have been included by Einstein by altering slightly the expression for the element of length δs, but so that it becomes expressed by the general quadratic function of the elements of length. If now a new dimension ζ, preferably of space, be introduced, so that $\delta s^2 = \delta x^2 + \delta y^2 + \delta z^2 + \delta \zeta^2 + \delta w^2$, $w = \sqrt{-1}ct$, with a corresponding additional component in the vector potential, Einstein's generalisation may be interpretable as the geometry of a 4-dimensional hypersurface in this 5-dimensional homaloid. In Minkowski's theory the hypersurface is taken as a hyperplane or hypersphere of extremely small curvature. Einstein's problem of including gravitation will mean the recognition of slight local deformations of the hypersphere as representing that effect. If the hypersurface, which is of very small and very nearly uniform curvature in the problem as presented in nature, can be so chosen that the rays of light shall remain geodesics on the locus determined by δs vanishing, and the free orbits of gravitating particles shall be paths of minimum length of the hypersurface—then one way of absorbing the universal phenomena of gravitation into the mixed time-space scheme which has arisen from and obliterated the previous idea of relativity of positions and motions will have been accomplished. So viewed, Einstein's solution along the lines of Hamiltonian variational dynamics is one of map-making in these hyperspaces. The result is that gravitation can be brought into the 4-dimensional scheme, which is independent of coordinate axes, at the cost of doing violence to electrodynamics by introducing complications too minute for observation, and to gravitation and its relations to light that happen to be just within the range of detection in these cases. It is as if a cap not fitting exactly over a surface could be made to fit by slight local stretching. The relativity established is so limited, holding for translation of the observer's system only when uniform, and for rotation not at all, that the theory should be designated, not a relativity theory, but a theory of interdependence of space and time, such that time is virtually a fourth dimension interrelated with the other three dimensions of space, and only in so far as its measure is a number that is algebraically a pure imaginary. Both position and motion are transcended by the theory, in any sense practically belonging to these concepts, and there seems no relevance in further discussion of their relativity. Propagation of radiation is transcended also; its velocity becomes merely the dimensional multiplier required to make time homogeneous with length. The result seems to strengthen rather than destroy the notion of an ether of space, for its aid cannot be dispensed with, and the theory shows that its mode of intervention is so fundamental as to be expressible in terms of many simple statements without mutual contradiction.

The author arrives at the conclusion that the theory does not warrant the supposition that the periods, terrestrially observed, of radiation from the sun or a star, should be displaced towards the red end of the spectrum. G. W. de T.

510. *Sources of Power.* **O. J. Lodge.** (Soc. Arts, J. 68. pp. 66–74, Dec. 19, 1919. Trueman Wood Lecture. El. Rev. 85. pp. 829–830, Dec. 26, 1919. Engineering, 108. pp. 796–797, Dec. 12, 1919. Abstract.)—After pointing out that power or energy is the most pressing material want of man, the author refers briefly to heat engines, including the utilisation of solar heat, best effected by promoting and improving agriculture. The water power of rivers is largely utilised; to utilise that of the waves along our coasts hardly seems practicable, but in his opinion is more so than that of the tides, a problem beloved of the amateurs but shunned by the engineers as economically impracticable. There are, moreover, two sources of energy discovered and as yet practically unutilised—one certain, the other rather hypothetical: the energy of the atom, and the energy of the ether. If the latter exists, as the author thinks it does, it is enormous, but at present is utterly beyond our reach. Atomic energy is much less, but immense compared with chemical or molecular energy. A beginning has been made in its utilisation therapeutically, and the author has recently suggested an incipient radio-active theory of vision, surmising the existence in the retina of a substance which can be stimulated into activity by the impact of ether waves of luminous frequency, and that it then ejects a few of its outlying electrons, which in their turn stimulate the nerve-endings in their immediate neighbourhood. For the accumulation of a few million impulses would take no appreciable time, and it is difficult to suppose that in any other way than by synchronisation with some equally rapid intrinsic motion could matter be perturbed by the extraordinarily rapid ether vibrations—hundreds of millions of millions per second. Nothing larger than the ultimate elements of the atom could be expected to follow such rapidity. Molecules of matter would be almost too massive to be moved as a whole; besides, their movement as a whole would result only in heat. The same might apply to the stimulus of a sensitive photographic plate; only here the chemical atoms are attuned, as a rule, to still higher rates of vibration, and are susceptible beyond the ultra-violet, into the region of X- and γ-rays. The absorption of solar energy by chlorophyll in plants may also in some way utilise atomic energy, stimulated into catastrophic activity by light waves, a problem well worth investigating experimentally. The application of atomic properties *in vacuo*, in the electric valve employed as a wireless telegraph detector by J. A. Fleming, is re-

ferred to, and its development into a relay or amplifier by de Forest, with its application to wireless telegraphy. In conclusion, the author observes that "the interest to us, here and now, is that it is by the harnessing and practical utilisation of purely atomic properties that all this great advance in practical electrical engineering has been accomplished." The conclusion is inevitable that much more remains to be done. G. W. DE T.

511. *Relativity of Natural Forces.* **J. Larmor.** (Roy. Astron. Soc., M.N. 80. pp. 118–138, Dec., 1919.)—The question at issue seems to reduce to this: whether it is safe to mix up a strict mathematical analysis of the modified space-time, required by the new relativity formulations, with an extraneous semi-metaphysical and loosely expressed "principle of equivalence," except in so far as verification of that principle is established as part of the analysis. Many mutually inconsistent correspondence schemes between the Minkowski 4-fold flat continuum and its curved substitute are in evidence. Notably, the quantitative marks of position in one scheme are arbitrarily transferred to another, and while the coordinates correspond, their higher spacial and temporal gradients differ. Consequently, the fundamental variational relation of dynamical science will work out so as to involve new terms in the resulting equations; and these terms would be interpreted as the expression of new universal forces in Nature, whereas they merely express the misfit arising from wrongly transferring the material system into an unsuitable frame of space and time, *e.g.*, all periods of time measured at the same place should be affected in the same way: thus, so far as such a theory can subsist, spectroscopic analysis should show no difference between H-lines of solar and terrestrial origin. Otherwise it would seem to be implied that light waves distribute throughout the universe the local time of their origin, a negation of all the modern relativity assertions. The correspondence can be fruitful only if the element of length be conserved. And this involves making the new element of extension, not merely correspond point for point to the original, but to be also superposable on it in Euclidean fashion, and hence a scale of length transferable (in an auxiliary space of higher dimensions—say, a 5-fold flat) from the one element to the other; in fact, applicable everywhere and in all directions. The Riemann specification is thus introduced, and the new time-space must be curved or warped essentially, in the sense of his analysis. The special postulate of the Einstein gravitation theory is the further restriction that the corresponding elements of extension should be equal, and it is this postulate, involving a slight misfit, which is responsible for the deviation of Einstein's law from Newton's. It is in no way necessitated for the absorption of gravitation in the new time-space, but it simplifies and promotes the inclusion in the scheme of the other main features of physical nature, the modes of operation of radiation and electricity, in some way perhaps capable of expression in direct physical terms. The effect of the postulate in a radial gravitational field (the astronomical case) requires a radial shrinkage of the space, which in the absence of an equal transverse shrinkage destroys its flatness; it is this which modifies gravitation. The deformation may be avoided by ascribing it to change of radial inertia with speed of the moving bodies, in extension of previous electrodynamic ideas regarding inertia; but then the doubled deviation of light becomes obscure. The form of least action employed permits the potential of the field to involve the time explicitly; but the gravitation sources must be practically stationary in comparison with the velocity of radiation. The course that is open is to start afresh with the widest possible foundation on the same lines, to eliminate inertia altogether, as it otherwise becomes mixed up with the varying scales of time and space, and to hold fast to the equations that remain—those of conservation of the transfer of energy and momentum in the field, subject to the activity of a working stress in the medium of the previously rather accidental Maxwell ether stress which thus receives a fundamental significance. This general theory, of immense analytical complexity, was apparently not required to predict the new effects on orbits and on rays, but it is the extension into conditions beyond present experience of a very remarkable and novel train of ideas into which these effects can be made to fit. G. W. DE T.

512. *Relativity Theory.* **J. H. Jeans, A. S. Eddington, F. W. Dyson, A. Fowler, E. Cunningham, F. A. Lindemann, L. Silberstein.** (Roy. Soc. Proc. 97. pp. 66–79, March 1, 1920. Discussion.)—**J. H. Jeans.**—The conservation of energy, the second law of thermodynamics, and relativity embody three principles, which limit the types of possible events, but are not concerned with their mechanism—with the how and the why of their occurrence. Historically, the relativity principle originated in the Michelson-Morley experiment, intelligible upon a corpuscular theory of light; but such a theory is difficult to reconcile with the majority of electromagnetic phenomena, and seems definitely negatived by Majorana's results—that the velocity of light is unaltered when emitted from a moving source or reflected by a moving mirror. Thus we have almost conclusive proof of the truth of Einstein's 1905 hypothesis that the wave-surface of light is invariably a sphere with the observer as centre—made far more conclusive in view of the fact that it explains a vast number of physical phenomena, and has, so far, not been found inconsistent with a single one. Suppose two observers moving with different speeds to pass through the origin at an instant $t = 0$, at which a light signal is emitted therefrom. Each will see the same wave-surface as a sphere with himself as centre, and a sphere has but one centre, so their coordinates must differ, and light travelling in straight lines at constant speed, the two sets of four rectangular coordinates locating the phenomenon in a Minkowski 4-dimensional continuum must be connected by a linear transformation, representing a pure rigid-body rotation, readily seen to be represented by the Lorentz transformation obtained as the condition that all optical and electromagnetic phenomena should be identical for all observers, regardless of their speeds. Nothing in physics has been found inconsistent with them—at least in the absence of a gravitational field—but they provide no physical interpretation. The first explanation was the Lorentz-Fitzgerald contraction, shown to be inadequate by Ehrenfest, in that the rim of a cartwheel turning about an axle at rest in the ether postulated would be contracted by its motion, while the spokes would retain their length unchanged—a wheel of radius a would have a rim of length $2\pi a/\beta$, where $1/\beta$ is the uniform ratio of contraction in the rim. In terms of the Minkowski continuum the contraction hypothesis becomes consistent and complete, the contraction in length being compensated by an expansion in time. The Minkowski *world-line* of a particle or light ray is an integral of its equation of motion. According to the Newtonian laws of motion the world-line

of a particle acted on by no forces is straight, and its equation is expressible in the invariant form $\delta\int ds = 0$, and is therefore the same for all observers. The general relativity condition is that *all* the laws of Nature shall be invariant as regards different sets of orthogonal axes in the continuum. The laws of light and electromagnetism agree experimentally with this condition. Not so, however, Newton's gravitation law which, therefore, if absolutely correct, would make it possible to determine absolute motion in space. Assuming this correctness, Lodge determines what velocity of the sun in space would account for the anomaly in the motion of Mercury. But Eddington showed that different velocities would be determined by the motions of the other planets. Einstein's first theory of gravitation was simply to modify Newton's law into conformity with the condition of invariance; but this only accounted for one-sixth of the anomaly in Mercury's perihelion, and a gravitational deflection of light about half that observed in the recent eclipse. In his second theory the continuum itself is supposed to have twists and kinks round and about the point-instants representing matter. Gravitation is no longer a physical force, but merely our interpretation of the fact that the continuum is not Euclidean. We are familiar with the conception of gravity acceleration on the earth as due partly to centrifugal force and partly to the earth's attraction. Our level surfaces are equipotentials under a potential $M/r + \omega^2(x^2 + y^2)/2$, and we were taught that the first term represents real, and the second term fictitious forces. The suggestion of generalised relativity is that the recognition that both terms represent fictitious forces will remove the troubles which have so far centred round the Newtonian law of gravitation. In the original continuum, the interval between two adjacent events is given by $ds^2 = dx^2 + dy^2 + dz^2 - c^2dt^2$, which is invariant for all observers. In Einstein's second theory this expression is true only at an infinite distance from all gravitating matter, and otherwise must be replaced by $ds^2 = g_{11}dx^2 + g_{22}dy^2 + 2g_{12}dxdy \ldots - g_{44}c^2dt^2$, in which $g_{11} > 1$, g_{12}, ... specify the gravitational field. And the values of the g's which conform to the relativity condition are practically limited to a single set, in which ds is given by $ds^2 = \gamma^{-1}dr^2 + r^2d\theta^2 + r^2\sin^2\theta d\phi^2 - c^2\gamma dt^2$, ... (A), where $\gamma \equiv 1 - 2M/rc^2$. There are, therefore, no adjustable constants, and this it was that enabled Einstein to predict a unique value for the light-deflection to be expected. A particle not acted on by electromagnetic forces will become a world-line which is a geodetic, *i.e.*, defined by $\delta\int ds = 0$, in the twisted space defined by (A). The simplest interpretation of ds is to regard it as an algebraic symbol defined by (A). Then the law of motion predicts Mercury's orbit and light-deflection, but not, the author thinks, a shift of spectral lines. Einstein gives ds a time-space interpretation—as a line element in a distorted space-time continuum. The hypothesis from which this is derived involves, Einstein considers, a shift towards the red, and the author agrees. It also involves an objective curved 4-dimensional space, a consideration of the limits of which discloses difficulties so grave that Einstein is prepared to abandon the whole central principle of relativity in an attempt to remove them. Without Einstein's interpretation of ds, the theory becomes less inclusive, and less beset by difficulties. The author considers the reality of the 4-dimensional continuum as beyond dispute, but not so that of the twists and kinks.

A. S. Eddington.—There are two methods of exploring space and time, and consequently determining the geometry of the space-time continuum:—(1) With scale and clock; (2) with moving particles and light pulses. They may give different geometries, each true in its own sphere. The author prefers the latter, the implements being simpler. The astronomer, by aid of his moving particles—the planets, especially Mercury—and by the light-pulses from stars during the solar eclipse, finds a geometry expressed by (A). Does (1) give the same result? Similar clocks will give similar values of the absolute thing, the interval ds; what they give in time depends on how the time is measured. Measuring it in the way usual for the solar system by t, and if the clocks be at rest so that r, θ, φ are constant during the vibration, (A) gives $dt = ds/\sqrt{(1 - 2M/r)}$. Thus, if the intervals ds be equal, the times dt will not. The clocks are atoms; the period of the solar atom can only be inferred from that of the waves after reaching the earth. It turns out, however, that the period reaches us unaltered—a result due to our judicious choice of the coordinate which we consider to be the time.

F. W. Dyson.—The hypotheses advanced in explanation of the anomaly in Mercury's perihelion motion are: (1) Oblateness of the sun; negatived by comparison with Jupiter and direct measures of diameter. (2) An intra-Mercurial planet; this has been looked for in eclipse expeditions, no unknown body being found, although stars down to the 9th magnitude have been photographed. (3) A ring of planets between Venus and Mercury, or between Mercury and the sun; such a ring would need to lie nearly in the plane of Mercury, or it would affect the movement of the node as well as the apse. Its existence is extremely improbable, and there is doubt if such a ring could be stable. (4) Extended matter whose presence is indicated by the zodiacal light; possible only on arbitrary and very improbable assumptions. (5) Change of the law of attraction from r^{-2} to $r^{-2+\delta}$, where $\delta = 0{\cdot}000{,}00016$, which would give the required movement to Mercury's apse, and would not disturb other planetary elements, but the assumption is quite arbitrary, and, moreover, is negatived by the movement of the moon's apse.

A. Fowler.—A summary of the observations relating to the shift of spectral lines is, in the author's opinion, decidedly unfavourable to the existence of the Einstein effect, necessitating extremely improbable assumptions for their explanation. A far more probable explanation of the mean results can be given on the assumption of its non-existence.

E. Cunningham.—Einstein's prediction of an observable shift of spectral lines involves his hypothesis of equivalence, as well as that of relativity. In a field free from gravitation containing two similar atoms, A and B, the arrival at B of waves from A must synchronise with the vibrations of B. If a gravitational field be simulated by viewing these atoms in a framework in which they have an accelerated motion, relativity requires that the synchronisation should continue, for a coincidence in the time-space cannot be resolved into non-coincidence. Then, as a real gravitational field may be simulated as far as the g_{rs} and $\dot{g}_{rs}$ are concerned, if the behaviour of the atom depends only on them, we may admit Einstein's assumption that ds as the measure of the interval between the emission of two successive pulses is the same for a given atom in all fields. But it appears that in a real field the transmission through the ether will not be such as to disguise the consequent change of period. Here, then, appears a real distinction between real and simulated gravitational fields. A revision and completion of the specification of stress, momentum, energy, and flow of energy requires a velocity to be attributed to the medium in which these exist, in order that the stress may account exactly not only for the flux of momentum, but for the flux of energy as suggested by Poynting. Analysis shows that along these lines an objective moving ether may be conceived consistent with relativity.

F. A. Lindemann.—The assumption that the atomic frequency, $\gamma = 2\pi^2 E^2 e^2 m/h^3$ × a pure number, is unaffected by a gravitational field seems doubtful. m increases—due to radial contraction—so as exactly to balance the Einstein effect, unless this increase is itself compensated by changes in E^2 and e^2. If so, the spectral shift would be required by the definition of ds. If not, its absence, if really absent, would be explained. Relativity seems to favour the undulatory view of propagation of radiation as opposed to light-quanta. If these existed, they would have a finite mass due to their electric field for an observer moving with them. This mass should vary with the velocity as that of an electron, and become infinite for any other observer. Incidentally, relativity deprives us of evidence for the assumption that an electron's mass is electromagnetic. Any mass would vary in exactly the same way.

L. Silberstein.—Einstein himself considers the spectral shift as theoretically unavoidable, and so do the leading Continental physicists, including W. Wien, who agrees with him that it is premature to see in the eclipse results a confirmation of Einstein's theory. G. W. DE T.

513. *Einstein Gravitational Deflection of High-speed Particles.* **L. Page.** (Nature, 104. pp. 692–693, Feb. 26, 1920.)—Starting with the equation $\delta\int\sqrt{(1+2m/r)(dr^2+r^2d\theta^2)-(1-2m/r)c^2dt^2}=0$, where m is the mass of the attracting body in astronomical units divided by the square of the velocity of light, an energy equation is obtained which, integrated approximately for the case of a speed comparable with c, gives $v^2 = c^2\left\{a^2(1-6m/r)+2m/r\right\}$, a being the ratio of the velocity of the particle at infinity to c. If a be small, we have the Newtonian energy equation. If the velocity at infinity be $1/\sqrt{3}c$, the tangential acceleration of the particle is zero throughout its motion through the field, and if headed directly for the attracting centre, it would move along a straight line with constant speed as if no field were present. For a velocity at infinity $>1/\sqrt{3}c$, v is actually decreased by the gravitational field. If it were aimed straight at the attracting mass, it would be slowed down as if *repelled* with a force varying inversely as the square of the distance. For a velocity at infinity equal to that of light, its velocity decreases as it approaches the attracting body by the same amount as that of a light-wave. But the deflection of a light-wave differs in nature from that of a particle. A light-ray is not bent towards the sun by the latter's gravitational attraction, but the velocity of that portion of the wave-front nearer to the sun is decreased more than that of the more remote portion. The wave-front is, therefore, swung round exactly as when light passes obliquely from a rarer to a denser refracting medium. The two consequences of Einstein's law, of magnitude amenable to observation, have been conspicuously verified. The predicted shift of spectral lines rests on the very doubtful assumption that the system of a freely moving atom near the sun's surface is identical with that of one 93,000,000 miles away. Since the warping of space-time is quite different near the sun and at the distance of the earth, these systems are not necessarily equivalent. It does not seem to the author that the failure to find such a shift invalidates the part of Einstein's theory from which his law of gravitation is deduced, and it certainly does not contradict this law itself. **A. S. Eddington.** (*Ibid.*, 105. p. 37, March 11, 1920.)—It would be difficult to reconcile Page's conclusion that a particle travelling with the velocity of light would be undeflected, whereas a ray of light would be deflected, with the principle of equivalence, which seems to require that the trajectory of a material particle should approach that of a light-pulse as the velocity approaches that of light. The author verifies, by the usual methods, Page's other principal results. He admits the non-identity of atomics on the sun and on the earth, but contends that it would be insufficient to account for the absence of observable shift. For the difference of the "intervals" of vibration must depend on some invariant of space-time which differs at the two places, and the simplest invariant which does not vanish is $g^{\mu\alpha}g^{\nu\beta}g^{\sigma\gamma}g_{\rho\delta}B^{\rho}_{\mu\gamma\sigma}B^{\delta}_{\alpha\beta\gamma}$, consisting of 65,536 terms, somewhat laborious to calculate, but seemingly of order m^2/r^2. The shift depends on terms of the much greater order of magnitude m/r. G. W. DE T.

514. *Einstein's Relativity Theory.* **J. Grommer.** (Preuss. Akad. Wiss. Berlin, Ber. 45. pp. 860–862, 1919.)—Einstein has drawn the conclusion [Abs. 906 (1918)] that, in a time-space *world* of approximately hyperspherical type, the total impulse vanishes and the total energy content has a constant value which, in the case of exact sphericity, is $c^2\varrho V$, where c is the velocity of light, ϱ the constant density of matter in *natural measure*, and V the volume of the hypersphere, also in natural measure. The conclusion depends on the assumption that a certain surface integral vanishes, and he gives reasons for the probability of this condition being fulfilled in the case of exact sphericity. The author here proves this generally for any quasi-spherical *world*, whatever the distribution and motions of the material content. G. W. DE T.

515. *Crucial Test of Einstein's Gravitation Theory.* **H. Jeffreys.** (Roy. Astron. Soc., M.N. 80. pp. 138–154, Dec., 1919.)—The author deduces, from the observed luminosity of the zodiacal light and the solar corona, the conclusion that the matter between the orbit of Mercury and the sun's surface is incapable of observable effect on the motions of the inner planets by its gravitation, or on the displacements of star images near the sun by its refraction. If the sun's gravitation be the cause of the Mercurial anomaly and the displacement of star images, then, considering generally any law of the form $\delta\int ds = 0$, where $ds^2 = \sum_i\sum_j g_{ij}dx_i dx_j$, covering practically any hypothesis amenable to the principle of Least Action, he finds that while a simpler theory than Einstein's would suffice to account for the Mercurial anomaly, it would not apply to objects moving with the velocity of light, actually giving only half the observed displacement of star images if supposed so to apply. The spectral shifts are discussed in detail, the conclusion being that they afford no satisfactory evidence for or against Einstein's gravitation theory, but fairly clear evidence against the assumption that the atom is a natural clock vibrating in the same period in the laboratory and on the sun. G. W. DE T.

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516. *Lunar and Rainy Periods.* **E. Mesnard.** (Comptes Rendus, 170. pp. 242–245, Jan. 26, 1920.)—The author maintains that at new and full moon certain phenomena are more likely. He finds in a period of 26 lunations, or 52 syzygies, that only 11 were inactive and 41 active, either with earthquakes, cyclones, tidal waves, etc., or with heavy rain. He considers it to be beyond question that nocturnal radiation, for instance, is more active at full, and especially at new moon. The argument is that the probability of earthquakes, volcanic eruptions, etc., is affected by the relative positions of the sun and moon, and that the weather is affected by the earthquakes, etc., and therefore indirectly also by the positions of sun and moon. There is so much indirect action that periodicity is inexact, and consequently forecasting uncertain, but the author is convinced of the reality of the connection. W. W. B.

517. *Self-luminous Night Haze.* **E. E. Barnard.** (Am. Phil. Soc., Proc. 58. pp. 223–235, 1919.)—Since the summer of 1910 the author has kept observation for self-luminous night haze in the sky. At times the phenomenon has been fairly frequently observed, but between October 1911 and June 1915 no record of it was obtained. Its presence seems to be independent of auroral conditions. Sometimes the luminosity appears in narrow strips, at others in broad sheets covering a large part of the sky; it is frequently brighter than the Milky Way. It seems probable that the appearance may be due to cirro-stratus cloud rendered luminous by some cause at present unknown. Full details of the individual observations are given. J. S. Di.

518. *Laws of Approach to the Geostrophic Wind.* **F. J. W. Whipple.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 39–53; Disc., 53. Jan., 1920.)—In enunciating the laws, use is made of the term "Relative Wind," that is, the vector which must be added to the gradient wind to form the actual wind at any height. The laws are: (1) The relative wind (R) falls off with height (z) according to the exponential law $R = R_0 . \varepsilon^{-B(z-z_0)}$ where B is a constant. (2) The direction of the relative wind turns uniformly with increase of height, its azimuth φ being given by $\varphi - \varphi_0 = B(z - z_0)$. (3) The angle between the actual wind near the surface and the relative wind there is 135°. From (1) and (2) it follows that the vector representing relative wind at different heights traces out an equiangular spiral with an angle between radius vector and tangent of 45°. Making certain assumptions which are set out, it is found that the first two laws are consistent with the conditions of the problem, and may be derived from them. The third law follows from Taylor's assumption that the only forces on the lowest layer of air which need be taken into account are the frictional drag and the drag due to eddies. The effects of the pressure gradient and the rotation of the earth may according to this view be neglected, since the two very nearly balance one another. This assumption is considered to be justified.

The important case where pressure gradient varies with height according to a simple law is next considered and diagrams show the relation of the actual wind to gradient wind at different heights. In the *discussion*, **L. F. Richardson** expressed the hope that the author would still further generalise his work to fit the case where eddy motion was not constant, but varied with height. J. S. Di.

519. *Observations of the Upper Air over Palestine.* **A. J. Bamford.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 15–32; Disc., 32–33, Jan., 1920.)—These observations in Palestine covered the period Sept. 1917 to Jan. 1919. The flights were observed during the first part of the ascent either with two theodolites or with one theodolite and a range-finder, so that the rate of ascent could be calculated. A series of ascents covering one year at Ramleh indicated that in the west-east wind component currents from the west predominated, the monthly means showing an almost entire absence of winds from east at all heights reached. At 10,000 ft. the west component reached 17 miles/hr. in March 1918, but decreased to 4 miles/hr. in October, rising again to 18 miles/hr. in December. In the south-north component there was much more variation in sign, the most noticeable feature being that this wind component from July to Oct. was consistently negative (wind from N.) in the lower layers and positive (from S.) in the overlying stratum, the level of separation falling pretty regularly from 8000 ft. in July to 1900 ft. in October. In the following month the lower current from north had disappeared. The variations in wind direction from month to month were very much greater near the surface than at 20,000 ft. height, where the mean monthly direction departed little from west throughout. As regards rising velocity of the balloons, this tended to be above the value given by the ordinary formula from 0–2000 ft. height, but below it at greater heights. The variations in individual cases about the mean were very considerable between 0 and 2000 ft., but became less pronounced in the succeeding layers. Frequency curves show no marked asymmetry about the mean value, *e.g.*, there were not a few rising velocities largely in excess balanced by many slightly in defect. Ascents made from Jerusalem showed a marked effect of the ground formation upon the rising velocity of the balloons. J. S. Di.

520. *Winds and Temperature Gradients in the Stratosphere.* **G. M. B. Dobson.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 54–62; Disc., 63–64, Jan., 1920.)—Some 70 cases where "ballons-sondes" have been followed by theodolites well into the stratosphere are examined, the figures being taken from the published data of the International Commission for Scientific Aeronautics. Plotting wind against height measured from the base of the stratosphere instead of from sea-level shows a gradual rise of velocity up to the stratosphere, followed by a remarkable falling off above this point. This occurs in nearly every case, both of medium and strong winds. Light winds do not show the effect. Wind direction shows little change at the base of the stratosphere.

From the wind distribution horizontal gradients of pressure and temperature at each height have been deduced for certain typical ascents. The pressure gradient remains nearly constant throughout the troposphere, but begins suddenly to decrease with remarkable rapidity as soon as the stratosphere is entered. The temperature gradients show that whereas in the troposphere the cyclone is cold and the anticyclone warm, on entering the stratosphere the conditions are reversed suddenly. The general results are in agreement with those obtained by taking mean temperatures from "ballons-sondes" ascents, but the suddenness of the change between troposphere and stratosphere is more strikingly brought out by the method here employed. In the *discussion*, **L. F. Richardson** suggested that component velocities were preferable to working with resultant velocity and direction. **F. J. W. Whipple** thought that the centrifugal action of the strong winds just below the stratosphere might provide a sucking action which would keep the cyclone in being. J. S. Di.

521. *Effect of High Temperature, Humidity, and Wind on the Human Body.* **C. W. B. Normand.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 1–11; Disc., 12–14, Jan., 1920.)—Under climatic conditions such that air temperature is above blood heat the gain of heat to the human body through convection may exceed the max. cooling power derived from perspiration. As the rate of gain of heat through convection increases with wind velocity, while the rate of perspiring has a definite limit, it follows that, under given conditions of relative humidity, to each air temperature above blood heat there must, theoretically at least, correspond a certain critical value of wind velocity which, if exceeded, will produce a net gain of heat to the body. Under these conditions it is assumed that continued existence becomes impossible. The greater the air temperature the lower this critical wind velocity becomes.

The human body may be regarded as somewhat similar in action to a wet-bulb thermometer, which maintains its temperature by a balance between convection and evaporation. In the paper a curve is worked out by means of the wet-bulb formula, showing the conditions of air temperature and relative humidity under which a wet-bulb thermometer at blood temperature neither gains nor loses heat in a given wind velocity. Under all conditions of temperature and humidity which represent points on the diagram on one side of the curve there will be a net gain of heat, and under conditions representing points on the other side a net loss. The human body cannot supply perspiration at more than a certain rate, which is analogous to a wet-bulb thermometer having a definite fixed max. rate of supply of water. The modification in the above curve introduced by this condition is investigated. By this means the conditions of temperature, relative humidity and wind under which human life is possible are indicated with such accuracy as our present knowledge of the different conditions involved allows. As an example, with temperature at 122° F. and humidity at 8%, life becomes impossible with a wind velocity above 15 m./sec. The fatal simoon may be explained by this means. J. S. Di.

522. *Frazil and Anchor Ice.* **J. Murphy.** (Canad. El. News, 29. pp. 31–32, March 1, 1920. Paper read before the Eng. Inst., Canada.) —Experiments are described showing that frazil and anchor ice are formed at 32° F. by the agitation of the water. The water was agitated by metal rods. The frazil ice attached itself to the rods and the anchor ice fell to the bottom of the vessels. The frazil became more dense as the agitation proceeded. It was further shown that if the agitating rod is 1 deg. F. above freezing-point, ice is not formed. Ice can therefore very easily be prevented from forming—a small amount of heat introduced into the machinery is all that is necessary. It is stated that if the metal is as little as a thousandth part of a degree above freezing-point no ice will be formed. W. A. R.

523. *Equal-Density Surfaces in the Earth's Interior.* **C. Gorceix.** (Comptes Rendus, 170. pp. 57–60, Jan. 5, 1920.)—At the time of con-

solidation it is reasonable to suppose that the earth's materials arranged themselves according to density in beds separated by level surfaces. The surfaces of equal density can no longer be level. The surfaces may even be discontinuous and the original order of density may be no longer observed.

The position with respect to the level of isostatic compensation of the surface where there is a mean specific gravity of 2·8, separating the upper crustal rocks from the lower, viscous sub-crustal matter is examined. It is found that this density surface is nearer the isostatic level under continents than it is beneath ocean basins. Under the former it rises towards the isostatic level in proportion to the surface relief; and under the latter it goes deeper than the isostatic level by amounts increasing in proportion to the depth. W. A. R.

524. *Barometric Pressure and Underground Water-level.* **E. G. Bilham.** (Roy. Meteorolog. Soc., Quarterly J. 46. pp. 35–38, Jan., 1920.)—The relation between the height of the water in a well at Kew Observatory and the barometric pressure has already been investigated by the author [see Abs. 235 (1918)]. The rise of water-level per unit fall of pressure was found to fluctuate between 0·5 mm. per mb. when the water-level in the well was low, and 4·0 when the level was high. Old records of a well at Maghull near Liverpool now analysed show values of 2·1 and 3·6 mm. per mb. change of pressure on the occasions of two periods of large barometric fluctuation in 1883. In correspondence with the author, J. Baxendell suggests that the variation in sensitiveness may be dependent upon change in the dampness of the overlying soil, rather than on the height of the water in the well. J. S. Dr.

525. *Emergence Angle of Earthquake Waves, and Poisson's Constant for the Uppermost Earth Layer.* **C. Mainka.** (Phys. Zeits. 20. pp. 574–579, Dec. 15, 1920.)—The author commences with a definition of emergence angle. After this Schuster's work is referred to, wherein it is shown that the earth particles at the surface are influenced not only by the direct, but also by the reflected waves. In consequence seismographic data include these compound effects, and an apparent emergence angle results. Schlüter and Galitzin's measurements and calculations then receive attention, following which the author establishes a relation between the emergence angle and the Poisson constants. Tables of data are given, and a discussion of seismometers concludes the paper. H. H. Ho.

526. *Tides on a Rigid Earth.* **F. R. Moulton.** (Astrophys. J. 50. pp. 346–355, Dec., 1919.)—The experiments of Michelson and Gale on tides in short channels of water gave results so precise that it is necessary to develop tidal theory to an extent not hitherto required. The surface of water in a partially filled pipe is an equipotential surface for all the forces which act upon it. The periods of waves otherwise produced are so short that they cannot be confused with tidal oscillations. Therefore, theoretical tidal expressions are developed here only for equipotential surfaces; and the expansions are worked out to sufficient terms to determine the theoretical tides to within one-tenth of one per cent. of their values. W. A. R.

527. *Formation of a Single Celestial Body in an Infinite Homogeneous Nebula.* **A. Véronnet.** (Comptes Rendus, 170. pp. 40–42, Jan. 5,

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1920.)—The introduction of any mass into the system of molecules in equilibrium starts concentration about it, and the author derives equations for the uniform spherical concentration, from which he concludes that the masses formed are exponential functions of the time and of the square root of the density of the medium. In the same time and the same medium they remain proportional to the masses of the primitive centres of attraction. For a density equal to that of the whole sphere of the solar system he finds the time of formation of a mass equal to the sun, starting from various primitive masses. Thus 41 million years if the primitive mass is equal to that of the earth, and 384 million years if the primitive mass is 1 gm., but in any case only 20 million years are required to bring the mass up from $\frac{1}{1000}$ that of the sun, and 7 million years to bring it up from $\frac{1}{10}$. A single atom would have been sufficient to form a sun in less than 400 million years. He therefore objects to the loose expression hundreds of millions of years for the period of evolution. In media of different densities the time of formation is inversely proportional to the square root of the density. With density one-fourth of that assumed above, the time would be doubled, so that a primitive mass equal to the earth would in 40 million years, instead of reaching the mass of the sun, only reach $\frac{1}{1000}$ of it, and would still be in a nebulous condition. With density four times as great as the original assumption, a primitive mass equal to the earth would have reached that of the sun in 20 million years, and for the remaining 20 million years would have cooled off again, forming a region of dead or declining objects. Very small differences of density of the medium thus make enormous differences in the stage of evolution. The author concludes that the Milky Way represents a region of different density from those above and below it, where nebulæ are found in greater numbers. W. W. B.

528. *Mount Wilson Observatory* 100-*inch Telescope.* **H. S. Jones.** (Observatory, No. 550. pp. 122–124, March, 1920.)—Comparisons are given of the efficiency of the 60-in. and 100-in. telescopes. For instance, with the new instrument good spectrographs of stars of class Md are obtained in two hours or under, as against five hours with the 60-in. Shapley finds a gain of one magnitude in investigating star-clusters; and also that spectra which overlap in the focus of the 60-in. can be separated with the 100-in. Hooker telescope. Two specimens are given of lunar photographs; these show the best definition yet obtained. A very delicate application of Michelson's interferometer method to the 100-in. has enabled the separation of the components of Capella to be measured at 0·042″. From a set of measures of this kind in conjunction with the spectroscopic observations it will be possible to determine accurately the parallax and mass of Capella. W. W. B.

529. *Investigation of a Diurnal Variation of Latitude.* **J. Boccardi.** (Comptes Rendus, 170. pp. 381–384, Feb. 16, 1920.)—The author gives a *résumé* of a memoir about to appear dealing with a set of observations made at the Royal Observatory of Turin by three observers, sometimes assisted by a fourth, maintaining a regular interchanging series of watches by night with an instrument in the Prime Vertical, on a list of 10 stars passing near the zenith. The stars were of magnitudes 2·3 to 7·1, but were equalised by muslin screens. He details other precautions taken to ensure accuracy. The complete series will cover eight months, but was not ended at the date of this paper. The preliminary result does not seem likely to be modified seriously. A diurnal variation is found of $\mu \cos (\nu + \theta')$, where μ is a constant between 0·05" and 0·07", ν an arc corresponding to zero of sidereal time at the epoch of commencement, and θ' the sidereal time elapsed (which may include many whole revolutions), multiplied by 1·0007 (approximately), so that the phase increases about 1° in four days. From a table comparing observed with calculated values, it appears that no residual exceeds 0·04". W. W. B.

530. *Asymptotic Satellites near the Equilateral-Triangle Equilibrium Points in the Problem of Three Bodies.* **D. Buchanan.** (Cambridge Phil. Soc., Trans. 22. pp. 309–340, Oct., 1919.)—In the restricted problem of three bodies, when the third is infinitesimal, there are five equilibrium positions: three in the straight line joining the two finite bodies, and two making equilateral triangles with the positions of the two bodies. This paper is concerned with these last two points, similar papers dealing with the straight-line equilibrium points having appeared before. It is not concerned with oscillating satellites, initially slightly displaced from equilibrium points so as to describe closed orbits about them, but with an initial disturbance under conditions leading them back to the equilibrium point, or to a periodic orbit about it, only after an infinite time. The author treats first of the two-dimensional problem where one of the two finite bodies is very small compared with the other, and the motion is all in one plane. In this case the convergence is to the equilibrium point itself. Afterwards he takes the more general case of three dimensions with the same restrictions of relative mass, but in this case the approximation is to the three-dimensional periodic orbit about the equilibrium point. He states also the conditions for convergence in the solutions, giving in each case a numerical example, with diagrams. W. W. B.

531. *Disturbed Sun-spot Area on Sun's E. Limb,* 1919, *May* 29. **A. L. Cortie.** (Roy. Astron. Soc., M.N. 80. pp. 204–205, Dec., 1919.)—On the eclipse day a disturbed region extending from long. 356° to 30° and lat. 0° to 25° N. was on the sun's limb, the disturbance itself having been noted from April 6 to Aug. 24. The author refers to a previous paper [Abs. 820 (1915)], in which coronal streamers were shown to be connected with areas of long-continued activity, in the case of the eclipses of 1893, 1898, 1905, 1908, and 1914. The present paper refers the eclipse prominence to the disturbed region, which the author estimates as covering an arc of 65° of the sun's limb, including a strong upcast at 40° S. lat. bending over northwards to the sun-spot region. W. W. B.

532. *Flash Spectrum.* **S. A. Mitchell.** (Am. Phil. Soc., Proc. 58. pp. 265–268, 1919.)—The author gives a sketch of the history of eclipse spectroscopy in reference to the flash spectrum discovered in 1870, until his own successful measures in 1905, of 2841 lines between λ 3300 in the violet and the D_3 line in the yellow. His conclusions at that time were:—(1) The "flash" spectrum is a reversal of the Fraunhofer spectrum. (2) The chromospheric lines appear gradually, not instantaneously, the highest lines in the sun's atmosphere appearing first. Most of the low-level lines come from the "reversing layer" of about 600 km. in height. (3) Wave-lengths in chromospheric spectrum are practically identical with those in solar spectrum. (4) The intensity is greatly different. H and He in chromosphere point to a spectral type earlier than the solar. (5) This is to be explained by the height of the vapours. (6) Enhanced lines very prominent in chromosphere.

Great preparations were made for the 1918 eclipse with great dispersion, but it was cloudy at all stations making a special feature of the "flash" spectrum. W. W. B.

533. *Lick Observatory's Crocker Eclipse Expedition, June 8, 1918.* **W. W. Campbell.** (Am. Phil. Soc., Proc. 58. pp. 241–254, 1919.)—Premising that the principal objects of eclipse observers are to throw light on the structure and cause of the solar corona, the author gives a list of eclipse problems in the light of 1918 and previous results.

(1) *Form of corona.*—Not quite as predicted, the relationship with sun-spots though obviously existing, is not yet defined, nor explained. (2) *Coronal streamers related to other phenomena.*—It is not yet proved that the hooded streamers are controlled by centres of disturbance in spots or faculæ. (3) The forms of coronal streamers are suggestive of magnetic control. (4) *Motion in corona.*—Examination of plates suggests motion both inward and outward. More evidence is desired, and photographs have been sent to other observatories in the hope of finding it. (5) *Polarised light in corona.*—This seems strongly established, but it is suggested that the apparatus may not be above suspicion. (6) *Spectrum of corona.*—Continuous radiation of bright inner corona is very slightly affected by Fraunhofer absorption, so that inner corona is probably incandescent. The outer corona does contain Fraunhofer lines. A warning is given against using spectrograms obtained through light clouds. (7) *Rotation of corona.*—Evidence so far is inconclusive in favour, but there is none against. (8) *Wave-lengths of coronal bright lines.*—Improved accuracy is attainable for at least six coronal lines, but it may be better to concentrate attention on one at a time. (9) *Brightness of corona.*—Suggested differentiation of outer, middle, and inner corona, and also correlation with sun-spot phase. (10) *Flash spectrum.*—Special apparatus and great care required to obtain data for limiting depths of absorptive strata. (11) *Contact times.*—The really important ones are second and third contact; large scale photographs are suggested for this purpose. (12) *Accurate position of the Moon.*—Attention is drawn to errors in predicted place; meridian observations shortly before an eclipse are desired. (13) *Einstein effect.*—Plates for this purpose obtained by the expedition are not yet measured on account of the photographer's call to war service. Further suggestions are made as to the best way of guiding the telescope for the purpose. (14) *Vulcan problem.*—It is recommended that the Einstein plates should be considered sufficient for the purpose of finding any intra-Mercurial planet.

The list of problems is not exhausted, but no more are specified.

W. W. B.

534. *Yerkes Observatory Eclipse Expedition, June 8, 1918.* **E. B. Frost.** (Am. Phil. Soc., Proc. 58. pp. 282–288, 1919.)—Of the three stations occupied by the Yerkes observers, one, near Matheson, Colorado, had fine weather for the eclipse, at which good photographs of the corona were obtained. It was quite cloudy at the Chamberlin Observatory of the University of Denver, where the director allowed the Yerkes

party the use of the 20-in. equatorial, so that the special plan for determining if possible the rotation of the corona could not be tried. The main expedition to Green River, Wyoming, at an altitude of 6200 ft., also suffered from cloud, but through the edge of a cloud some photographs of the corona and prominences were obtained, from which Barnard inferred a connection between coronal streamers and prominences. The author's intended test of the rotation of the corona by interferometer methods could not be tried as special apparatus arrived too late, but the method, though difficult, is strongly urged for future use. To avoid the composite nature of the usual photographs of the "flash" spectrum a moving-picture camera was employed, at a speed of 16 pictures per sec., involving about $\frac{1}{30}$ sec. for each actual exposure. This method also ensures the best moment being taken for the "flash," a matter of some doubt in previous eclipses, and the author suggests some modifications, such as a graduated rate of exposure, to give shorter exposures while the bright arc is disappearing and longer ones as totality is beginning. Unfortunately no first-class picture was obtained in this way at the 1918 eclipse. Other schemes were also spoiled by the cloudy conditions, but the photometric study of the corona revealed the fact that the great "heliosaurus" prominence was only visible in the H and K lines of calcium. W. W. B.

535. *Mt. Wilson Observatory Eclipse Expedition, June* 8, 1918. **J. A. Anderson.** (Am. Phil. Soc., Proc. 58. pp. 255–258, 1919.)—A list is given of the instruments used and the purpose of each, with details of improved methods of setting the slits of the spectrographs to obtain the best results at every stage of the eclipse. A large cloud obscured the sun from a few minutes after first contact until a few minutes after third contact, but the programme was carried out, the sun being visible through thin cloud, with light perhaps one-tenth of normal. Most of the photographs are in consequence very faint. W. W. B.

536. *Lowell Observatory Eclipse Observations, June* 8, 1918. **C. O. Lampland.** (Am. Phil. Soc., Proc. 58. pp. 259–264, 1919.)—This gives a preliminary account of prominences, and outer and inner corona, from a series of photographs obtained at Syracuse, Kansas. Detailed descriptions are not given, but it is noted that all the prominences with one exception are surrounded by arches of coronal matter, a characteristic of sun-spot maximum, said to be conspicuously absent at sun-spot minimum. The relation between the two is not universally admitted.

Spectrum observations show a continuous spectrum of inner corona, crossed by three coronal emissions, $\lambda\lambda$ 4086, 4231, and 5303, and a faint solar dark-line spectrum apparently of coronal origin for the outer corona. Coronium appears abundant where prominences and coronal extensions are found, but scarce in the regions of streamers such as the polar ones. W. W. B.

537. *Sproul Observatory Eclipse Expedition, June* 8, 1918. *Coronal Arches and Streamers.* **J. A. Miller.** (Am. Phil. Soc., Proc. 58. pp. 272–281, 1919.)—This expedition was at Brandon, Colorado. The author's intention was to secure, if possible, data bearing on the origin of the corona and the nature of the forces that produce it and control its shape, the principal points being (1) change of form during the eclipse,

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and (2) general form of streamers. Sproul plates were compared with eclipse plates from the Lick Expedition to Golden Dale (Washington) and the Naval Observatory Expedition to Baku City (Oregon). Three important prominences clearly identified on all the plates gave the following results:—Arch round S.E. prominence, receding 90 miles per sec; arch round pyramid, receding 60 miles per sec.; and skeleton, receding 15 miles per sec. The author is satisfied that these arches were going outward from the sun in the 25-minute interval.

The author had previously regarded streamers as projections, on a plane perpendicular to the line of sight, of streams of particles ejected, according to centrifugal force, solar gravitation, or radiation-pressure. Tested on suitable photographs, this explanation is not quite successful; so the mechanical theory may be wrong, though the author still considers it applicable to the long streamers. The corona may very likely be a magnetic or electric product, and the article ends by quoting L. Bauer's conclusions from magnetic observations in connection with the eclipse. W. W. B.

538. *Photoelectric Photometry of the* 1918 *Eclipse*. **J. Kunz** and **J. Stebbins**. (Am. Phil. Soc., Proc. 58. pp. 269–271, 1919.)—After unfavourable preliminary weather, clear sky appeared just two minutes before totality. Four complete measures were obtained of the light of the corona and of sky background.

Total light of corona after correcting for atmospheric absorption was 1·07 candle-metres, or half that of the full moon. Previous photographic results have ranged from $\frac{1}{40}$ to ten times moon's light, the best ones about $\frac{1}{10}$ full moon, while visual results ranged from $\frac{1}{4}$ to full moon.

The decrease in skylight due to the moon's shadow was 6000-fold. Hence not more than 1 % of general sky illumination during an eclipse can come from the corona.

The corona gives one-tenth of the light of a circle of daylight sky of the same area as the sun, but 8° away. It is therefore proposed to use photoelectric cells in an attempt to detect the corona in full sunshine. W. W. B.

539. *Birth of the Moon*. **W. H. Pickering**. (Pop. Astron., Oct., 1919. Nature, 104. p. 479, Jan. 8, 1920. Abstract.)—Recent geological opinion dates the earth's crust formation twenty times as far back as Darwin's estimate of the moon's age. To reconcile this, the author suggests that during the huge interval the moon's mass circulated as a cloud of fragments with small tidal effect, so that it would hardly modify the earth's primitive rapid rotation period of about four hours This speed involves a great lessening of gravity in the tropics, thus accounting for the size and capacity for flight of some of the prehistoric monsters. He suggests the middle of the Cretaceous Period for the consolidation of the moon, causing huge tides, which would account for the convulsive and volcanic activity of which there is geological evidence. W. W. B.

540. *Perihelion Movement of Mercury and Light Deflection on Weyl's Gravitation Theory*. **W. Pauli, Jr.** (Deutsch. Phys. Gesell., Verh. 21. pp. 742–750, Dec. 5, 1919.)—Weyl found, in his first publication, that the gravitational equations evolved from his principles would not pass over into those of Einstein in the absence of an electromagnetic

field. The author has already shown that on the assumption of 2 out of the 3 simple invariants which concern the world function, every solution of the Einstein equations, $R_{ik} = 0$, is satisfied, and at the same time those of Weyl. These are the invariants $R_{ik}R^{ik}$ and R^2. Weyl has recently put forward the view that the third invariant $R_{iklm}R^{iklm}$ is that particular world function which corresponds to reality. Weyl is convinced that the Newtonian law follows as a first approximation, but does not deal with the perihelion motion of Mercury. The present author now investigates this problem, and derives the differential equations for the gravitational field of a mass-point which follow according to Weyl's theory from the principle, $\delta\int R_{iklm}R^{iklm} = 0$. The integration is given generally up to magnitudes of the second order. In the solution, a second arbitrary integration constant occurs in addition to the mass of the field-producing body. It is then shown that the Einstein field

$$g_{00} = 1/h^2 = 1 - 2m/r, \quad \Delta = 1,$$

is a rigid special solution of the differential equations of the problem. From this it follows that the expression employed for the world function, which Weyl believes to correspond with reality, is not in contradiction with the observed perihelion motion of Mercury and with Einstein's value for light deflection.

The paper concludes with some observations on the problem of matter. [Abs. 25 (1920) and 375 (1919) should be consulted.]

H. H. Ho.

541. *Gravitation and Light.* **O. J. Lodge.** (Nature, 104. p. 372, Dec. 11, 1919.)—The author suggests the employment of a heliometer to test the Einstein deflection in the case of Jupiter passing between two stars whose distance apart is twice Jupiter's diameter and the theoretical displacement a sixtieth of a second of arc. W. W. B.

542. *Deflection of Light during Solar Eclipse.* **A. Schuster.** (Nature, 104. p. 468, Jan. 8, 1920.)—Anderson [Abs. 360 (1920)] disregards the shallowness of the effective layer of air as compared with the diameter of the moon's shadow. Unless the sun were very near the horizon, a line of sight drawn from the centre of the umbra to a point in the corona would remain within the umbra right through this layer, a consideration which vitiates his solution. But his slip of taking the sun's radius as 0·5 deg. in place of 0·25, undervalues the angular deviation. The author proposes shortly to publish a complete solution of the atmospheric refraction problem, which is fatal to Anderson's contention. **A. Anderson.** (*Ibid.*, p. 563, Jan. 29, 1920.)—The author gives the details of his endeavour to obtain a rough value for the refractive effect of the atmosphere during a total solar eclipse. In reference to Schuster's criticism he explains that he never thought of a ray that, in its passage through the earth's atmosphere, lay partly inside and partly outside the umbra. He thanks him for his correction in respect to the angular radius of the sun's disc. G. W. DE T.

543. *Einstein's Deflection of Light.* **A. C. D. Crommelin.** (Nature, 105. pp. 23-24, March 4, 1920.)—The author replies to suggestions as to possible "Einstein" effects on stars apparently close together, showing

that any such effect is quite evanescent in the case of a binary, and too small to be seen in the case of an optical double, when one star is twice as far away as the other. Another suggestion that an optical image of the more distant star might be formed by rays passing close enough to the nearer star to be deflected is also considered, and the author shows that in this case the image, if formed, is far too faint to be within the reach of the most powerful telescopes. W. W. B.

544. *State of Dissociation of Gases of the Stars.* **J. Eggert.** (Phys. Zeits. 21. pp. 570-574, Dec. 15, 1919.)—During recent years A. S. Eddington has put forward a new theory for the internal structure of stars [see Abs. 893 and 1258 (1917)]. The earlier theories [see Abs. 253 (1918)] depended on the assumption that the fixed stars, regarded as gas spheres, are in a state of equilibrium, and gravitation directed to the middle point of the star is raised by the contrary-acting gas pressure. Eddington has introduced the radiation-pressure as a new moment into this consideration, while he generalises the radiation equilibrium of Schwarzschild, found for the outer surface layer of the sun, to the relations within the entire interior of the star. According to Eddington the gravitation of the gas particles, on the one hand, and the sum of gas and radiation pressures on the other are in equilibrium for every star. The theory seeks to explain the fact that the masses of all stars lie dimensionally between 10^{33} and 10^{34} gm. Other experience, such as the connection between star density, effective temperature and brightness, is in agreement with the consequences of the Eddington theory. For the evaluation of his differential equations, Eddington uses the atom weight of the fixed-star gas, and claims a very profound atomic dissociation. The first value of the average atomic weight was about 2, but later revision pointed to 2·8.

The object of the present paper is to discuss the problem of atomic dissociation from the thermodynamic standpoint, the values of the various magnitudes involved being calculated on the Eddington theory. By means of the Nernst heat theory, the Sackur-Tetrode-Stern relation on the dimensions of the chemical constants, and Bohr's atomic theory, it is sought to what degree an atomic dissociation in nucleus and electrons is possible within a temperature range of 10^6 to 10^7 degrees and at a pressure of 10^7 atmospheres. The calculation points, on the assumption of a definite atomic model, to the splitting off of the two extreme electronic rings (16 electrons) as the upper dissociation limit. The average atomic weight of the fixed-star gas is found to be 3·3, which is near to the Eddington value of 2·8. H. H. Ho.

545. *Monochromatic Photographs and Photometric Measures of Dumbbell Nebula (N.G.C. 6853).* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 80. pp. 200-204, Dec., 1919.)—The author thinks this nebula should be classed as planetary, as having a definite compound elliptical outline with a central star, and as yielding a gaseous emission spectrum. He considers the division between ring and planetary nebulæ to be arbitrary and unnecessary, nearly all of both classes being in or near the Milky Way, and probably representing the later stages of novæ. He compares the light-distribution along these different diameters of the nebula through the central star, and considers that the shape of the nebula is a hollow gaseous spheroid. Experiments were made with different plates and different exposures, with and without an æsculine screen to cut out the ultra-violet radiation. W. W. B.

546. *Gravitational Displacement of Spectral Lines in Fixed Stars.* II. **E. Freundlich.** (Phys. Zeits. 20. pp. 561–570, Dec. 15, 1919.)—For the helium (B) stars and for the K and M stars statistics are brought forward in support of the view that it is possible to separate the mean gravitational effect from the Doppler-effect. There is apparently a general displacement towards the red of the spectra of these stars, as is to be expected from the general relativity theory. That this red-ward displacement of the spectra of the B stars is not a Doppler-effect, but is due to the conditions of emission at the surface of the stars, is supported by the general displacement towards the red of the spectra of the stars of the Orion nebula group, as compared with the spectrum of the nebula. [See Abs. 1212 (1915).] A. W.

547. *Distribution of Stars and Luminosities.* **J. Halm.** (Roy. Astron. Soc., M.N. 80. pp. 162–198, Dec., 1919.)—The author endeavours to find a general form for the luminosity function representing the distribution of stars about the sun as centre. He discusses the statistics available in the form of (1) the relation between apparent magnitude (photographic and visual) and star numbers in different galactic latitudes; (2) the relation between apparent visual magnitude and mean parallax in different galactic latitudes; and (3) the distribution in distance of stars of given apparent magnitude. This involves suggested systematic correction of magnitude standards adopted in different investigations, and also correction of adopted colour scales. It then becomes necessary to find some means of deciding between two alternative hypotheses as to the distribution and luminosity function. The author's provisional *conclusion* is against the hypothesis of a luminosity law independent of position, and therefore in favour of one where the luminosity does depend on the position. He admits the importance of increased accuracy in the data, but expresses his conviction that the usual ideas must be revised and that instead of a regular distribution of luminosity with an irregular arrangement of star matter, we have a regular distribution of star matter with an irregular arrangement of luminosity, so that apparent condensations are mainly optical effects, and the stars in the galaxy, for instance, are not more crowded, but simply brighter on the average than in other parts of the sky. W. W. B.

548. *Spectrum of Nova Aquilæ,* 1919 *July–August.* **A. L. Cortie.** (Roy. Astron. Soc., M.N. 80. pp. 205–206, Dec., 1919.)—From photographs on Aug. 6 and 14, measures of the spectrum between λλ 3820 and 5140 show two principal nebulæ lines at 4363 and 5007, two other nebular lines, four of the hydrogen lines, two lines found in Wolf-Rayet stars, and two unidentified lines approximately at 3925 and 3949. There was also a faint continuous spectrum. A few visual observations showed the two brightest nebular lines and a line in the yellow, possibly D_3, superposed on a faint continuous spectrum. The star was of about 7th magnitude. W. W. B.

549. *Helium Lines in Novæ.* **W. S. Adams** and **A. H. Joy.** (Observatory, No. 549. pp. 86–87, Feb., 1920.)—The question having been raised

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by Baxandall [see Abs. 561 (1919)] as to absence of He in early novæ spectra, the authors have examined three early photographs of the spectrum of Nova Aquilæ. They find no evidence of He on June 8 and 9 (1918), but on June 10 a broad complex line at λ 4448·0. Resolving this with a more powerful instrument on June 11 and 12, they indentify 4468·7 Ti and 4471·6 He with a possible comparison He at 4438·4, giving a displacement − 33·2 Å. in good agreement with those of the H lines. The so-called "parhelium" lines, if present, are interfered with by strong absorption lines, and the authors conclude that they are of very low intensity, if present at all. W. W. B.

550. *Nova Lyræ.* **[Miss] Mackie.** (Harvard Obsy., Bull. No. 705. Nature, 104. pp. 704–705, Feb. 26, 1920. Abstract.)—R.A. 1900·0, 18h. 49m. 30s. N. Decl. 29° 6·3′. Between Dec. 4 and 6 it rose suddenly from 16th magnitude or fainter to 6·5, and by Jan. 6 had sunk to 8·5. Adams and Joy at Mount Wilson report characteristic nova spectrum. In the same message they report remarkable changes in the spectrum of Mira Ceti, the bright He and H lines being strengthened and widened towards the red. W. W. B.

551. *Proper Motions in Cluster N.G.C.* 663. **V. M. Gushee.** (Astron. J. 32. pp. 117–120, Nov. 24, 1919.)—Four plates were taken with the 40-in. Yerkes telescope, two in 1903 and two in 1916, the best plate showing 430 measurable stars; but for the purpose of determining P.M. the comparison plates should have good images also, thus the number available was reduced to 209. These were measured in four positions, each coordinate being reversed, care being taken to guard against temperature effects. The cluster was taken to include all stars within a radius of 15′ from the centre, and thus is found to include 21 B.D. stars, whose P.M.'s are given separately. The author intends to pursue the subject further, and to find the absolute magnitude of the stars, the proper motion of the cluster as a whole, and the preferential motions within it. W. W. B.

552. *Relative Masses of Binary Stars.* **G. van Biesbroeck.** (Pop. Astron., Jan., 1920. Nature, 104. p. 643, Feb. 12, 1920. Abstract.) —Photographs of binary stars are now being taken with the Yerkes 40-in. refractor, to determine the motion of each component with reference to the background of stars, and thus to find the ratio of the masses. Castor photographs 1916 to 1919 give motion in R.A. − 0·0167s. annually of brighter star and − 0·0118s. of fainter. Assuming Boss' value of the motion of the centre of gravity, − 0·0135s., the ratio is in this case 17 to 32, the faint star being 1·9 times as massive as the other. Boss assumed equal masses, but the same value − 0·0135s. was found on the assumption that the faint star was six times as massive as the bright one, so the value seems to be probably correct. The orbits of Procyon and ζ Cancri are also under investigation. The components of Procyon are too close for observation in part of the orbit, and it is hoped to bridge the gap by this method. W. W. B.

553. *Fourth List of Spectroscopic Binaries.* **J. S. Plaskett, W. E. Harper,** and **R. K. Young.** (Roy. Astron. Soc. Canada, J. 13. pp. 372–378, Oct., 1919.)—The three previous lists [see Abs. 869 (1919)] contained 50 binaries, and the present one adds a further 25, nearly all of 5th or

6th magnitude, but including one of 7·4 magnitude. The types are given, and also the measured radial velocities, with notes on the character of the lines. One orbit has been computed. W. W. B.

554. *Spectroscopic Orbits and Dimensions of Eclipsing Variables.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. 14. pp. 1–15, Jan.–Feb., 1920.)—Three stars are considered, U Ophiuchi, RS Vulpeculæ, and TW Draconis, but in the last-named the second spectrum could not be obtained, so that absolute dimensions are not available. The figures for the other two are tabulated with those of seven similar stars previously determined. In the cases of Algol, δ Libræ, and u Herculis, Schlesinger found the spectroscopic phase to be about an hour earlier than the photometric. The present author finds in RS Vulpeculæ the spectroscopic phase about 3 hours later, and in TW Draconis 27 minutes later, than the photometric. The observations of U Ophiuchi were unsuitable for this experiment. No explanation is yet suggested for this difference in the spectroscopic and photometric phases, and the variability of the sign of the difference is a difficulty which requires further data for its elucidation. W. W. B.

555. *Orbit of the Spectroscopic Binary Boss* 2285. **A. H. Joy** and **G. Abetti.** (Mt. Wilson Observat. Contrib. No. 172, Astrophys. J. 50. pp. 391–393, Dec., 1919.)—This star, with Boss 2286, forms the physical system B.G.C. 4677 = Σ1245. Results of 23 plates made in 1917–19 are tabulated, and the final elements given as: $U = 14{\cdot}296 \pm 0{\cdot}003$ days; $e = 0{\cdot}276 \pm 0{\cdot}021$; $K = 22{\cdot}74 \pm 1{\cdot}20$ km.; $\gamma = +\,24{\cdot}23 \pm 0{\cdot}62$ km.; $\omega = 220^\circ{\cdot}80 \pm 1^\circ{\cdot}98$; T = J.D. $2{,}421{,}599{\cdot}474 \pm 0{\cdot}157$; $a \sin i = 4{,}300{,}000$ km. H. F. H.

556. *Orbit of the Spectroscopic Binary Delphini.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 13. pp. 452–454, Dec., 1919.)—This star (1900 α = 20h. 33·0m.; $\delta = -\,11^\circ\ 02'$; Mag. 5·49; Type A2) was announced as a spectroscopic binary by Adams from 3 plates made in 1911. Results from these, and from 20 plates made in 1919, are tabulated, and the grouped velocities plotted on a graph. The final elements are: $U = 10{\cdot}9960$ days; $e = 0{\cdot}252 \pm 0{\cdot}025$; $K = 26{\cdot}72 \pm 0{\cdot}73$ km.; $\gamma = -\,5{\cdot}50 \pm 0{\cdot}52$ km.; $\omega = 60^\circ{\cdot}81 \pm 8^\circ{\cdot}19$; T = J.D. $2{,}422{,}095{\cdot}816 \pm 0{\cdot}237$; $a \sin i = 3{,}909{,}500$ km. H. F. H.

557. *The Orbit of the Spectroscopic Binary Boss* 4507. **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 13. pp. 455–457, Dec., 1919.)—23 plates were made in 1919 of Boss 4507 (1900 α = 17h. 44·4m.; $\delta = 47^\circ\ 39'$; Mag., 6·34; Type, A0), and the results are tabulated. The observations were made under very easy and satisfactory conditions, and the probable error of a plate is only ± 1·2 km. per sec., considered very good for single-prism work with dispersion of 35 Å. per mm., and for spectra with lines of only moderate sharpness. The final elements are: $U = 2{\cdot}82424$ days $\pm\, 0{\cdot}00011$; $e = 0{\cdot}017 \pm 0{\cdot}007$; $K = 60{\cdot}15 \pm 0{\cdot}47$ km.; $\gamma = -\,27{\cdot}30 \pm 0{\cdot}30$ km.; $\omega = 30^\circ$; T = J.D. $2{,}422{,}106{\cdot}713 \pm 0{\cdot}038$; $a \sin i = 2{,}335{,}700$ km. H. F. H.

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558. *Vacuum Spectrograph for the Study of the Extreme Ultra-Violet.* **L. and E. Bloch.** (Comptes Rendus, 170. pp. 226–228, Jan. 26, 1920.)—The spectrograph consists essentially of a fluorine prism of the Broca-Pellin constant-deviation type, associated with two fluorine lenses of 28 mm. aperture and about 12 cm. focal length, with appropriate mountings and adjustments. The whole of this apparatus is enclosed in a brass casting 2 cm. thick, which is closed by three thick brass plates, one above the prism and the others behind the slit and the photographic plate. Air-tightness is assured by means of greased joints. The plate opposite the slit is provided with a fluorine window, so that a light source can be used outside the spectrograph. The case is exhausted to a pressure of less than 0·001 mm., and a special arrangement allows the plate to be manipulated inside the chamber, so that a number of photographs can be taken on one plate. With this apparatus the spark spectra of different metals has been investigated down to λ 1550, the lines of aluminium and mercury (Lyman) and the nitrogen doublet $\lambda\lambda$ 1494·8, 1492·8 being used as standards. No results are given. A. W.

559. *Spark Spectra in the Extreme Ultra-Violet; Lyman's Doublet Observed.* **L. and E. Bloch.** (Comptes Rendus, 170. pp. 320–322, Feb. 9, 1920.)—With the apparatus previously described [see preceding Abs.] measurements have been made of the wave-lengths of numerous spark lines in the spectra of cadmium, bismuth, nickel, and silver. The measurements extend to λ 1550, but on many plates intense lines were obtained near λ 1400. Results for these will be given later. The source of light used was a condensed spark between metallic electrodes in pure hydrogen at atmospheric pressure. The wave-length tables give 14 Cd lines in the range λ 1845 to λ 1600, 23 Bi lines in the range λ 1824 to λ 1503, 59 Ni lines from λ 1849 to λ 1532, and 59 Ag lines from λ 1849 to λ 1496.

A very intense doublet is contained in the *spectra of Ni and of Ag,* in addition to the above lines. The measurements of wave-length in the two cases gave the values 1550·7, 1548·2, and 1551·3, 1548·7. This doublet seems to be identical with the doublet of unknown origin 1550·8, 1548·2 noted by Lyman. [See Abs. 1665 (1915) and 775 (1916).] A. W.

560. *Baker Air Sextant.* **T. Y. Baker.** (Optical Soc., Trans. 20. pp. 340–342, June, 1919.)—One of the difficulties in using an ordinary sextant in aircraft lies in the uncertainty as to the depression of the visible horizon below the true horizontal. In order to avoid this uncertain correction to the altitude of the heavenly body observed, the present sextant has been designed to utilise the part of the horizon directly below the sun or star, and also that part in the opposite azimuth. A telescope has the main part of its axis vertical, and has a right-angled bend produced by a prism near the eyepiece. Above the object glass is a plate upon which are mounted two prisms whose functions are to collect light from the front horizon and from the back horizon (directly behind the observer) respectively. The observer thus sees the front horizon the right way up, and the back horizon inverted. If it is assumed, as is normally the case, that the dip is of the same amount all round the horizon, then the true horizontal is half-way between the two visible horizons whatever the dip may be. Above the two horizon prisms is a third prism, which is used like the index mirror of an ordinary sextant to reflect the sun's image into the field of view, the light from this prism passing through a small circular hole drilled centrally through the two horizon prisms. With the graduations provided it is possible to make observations to 2 or 3 minutes. A. W.

561. *Fabry's Immersion Method for Refractive Indices of Solids.* **H. S. Uhler.** (Am. J. Sci. 49. pp. 143–145, Feb., 1920.)—Fabry's original paper was confined to standard prisms of 90° refracting angle [Abs. 1496 (1919)]. The present paper gives a proof of a generalised formula for prisms of any angle, and also a convenient alternative series which converges rapidly. The use of prisms of 90° refracting angle has the advantage of considerably simplifying the analysis. A. W.

562. *Shift of Spectral Lines on Einstein's Theory.* **J. Rice, A. S. Eddington.** (Nature, 104. pp. 598–599, Feb. 5, 1920.)—**Rice** proposes the two problems: (1) Light signals from S at start and finish of event are noted at A and A′, and the times thence determined as dt and dt'. Then $\sqrt{g_{44}}\,.\,dt = \sqrt{g'_{44}}\,.\,dt'$. (2) Events at S and S′ occupy times dt and dt' to local observers. By light signals at start and finish from S and S′ observer at A finds times equal. Then $\sqrt{g_{44}}\,.\,dt = \sqrt{g'_{44}}dt'$. (1) Seems a consequence of Einstein's theory; (2) would follow by applying (1) to event at S as observed at S and A, and then to event at S′ as observed at S′ and A. If correct, why the shift? The criterion for similarity of two radiating mechanisms in a gravitational field would seem to be that the invariant space-time elements corresponding to one oscillation of each should be equal. For two mechanisms at rest in the field this reduces to $\sqrt{g_{44}}\,.\,dt = \sqrt{g'_{44}}dt'$. **A. S. Eddington** replies that Einstein's shift prediction is analysable into the assertions:—(*a*) That the period of an atom at rest on the sun differs from that of a similar one on the earth; (*b*) that this difference is unchanged in light-waves travelling from sun to earth, and is therefore visible on earth. He regards *a* as probable, but not proved. The interval ds between two events has absolute significance, so for two events at same place, $ds = \sqrt{g_{44}}\,.\,dt$. Now (1) asserts that if two light-pulses travel from sun to earth, the interval ds between the passages through any point is the same throughout the track. This seems plausible, but not proved, since time-space near the sun is non-Euclidean. Einstein's theory involves—not $ds = ds'$, but $dt = dt'$, provided the coordinates be such that the velocity of light does not change with t; and with the coordinates generally used, the velocity is $1 - 2m/r$, which depends on the position, but not on the time. Larmor describes the condition that the velocity, or the formula for ds, shall not contain the time explicitly, as "a reasonable assumption" [see Nature, p. 530, Jan. 22, 1920]. The author cannot see that any assumption is involved, nor can he agree that it is of an absolute type. The expression $ds^2 = -(1 - 2m/r)^{-1}dr^2 - r^2d\theta^2 - r^2 \sin^2 \theta d\varphi^2 + (1-2m/r)dt^2 \ldots$ (A) is a particular integral of Einstein's differential law of gravitation, and can be proved an appropriate solution for an isolated particle. But there is a 4-fold infinity of other solutions, so there can be nothing absolute about this solution or the coordinates r, θ, φ, t, which it defines. There can be no exact identification of variables in a non-Euclidean world with quantities the definition of which presupposes a Euclidean world, for results may be exactly stated in the form :—At a point in the laboratory, for which r = constant, dt_1 for a light vibration from a solar atom differs from dt_2 for a terrestrial atom. Hence, from (A), ds_1 and ds_2 will differ in the same ratio, since it is here a question of dt and ds on the earth only. The intermediary quantity t is thus eliminated; and the difference in the light received from solar and terrestrial sources is an absolute one, which it is hoped the spectroscope will detect.

G. W. de T.

563. *Minimum Dispersion of a Prism.* **H. Erfle.** (Zeits. Instrumentenk. 39. pp. 280–288, Sept., and pp. 297–312, Oct., 1919.)—Commences with a short account of previous work on the subject of the angle of minimum dispersion in the principal plane of a prism of given angle. A simple formula is given for the determination of this angle, as well as for the critical prism angle at any given value of refractive index. If this latter angle is exceeded, there is no position of minimum dispersion, but the dispersion is least with grazing incidence. Approximate formulæ are given for the amount of the dispersion in the case of grazing incidence, minimum dispersion, and grazing emergence. Only at nearly perpendicular emergence is the separation proportional to the difference of refractive index.

J. W. T. W.

564. *A Method of Measuring Atmospheric Transparency.* **A. Blondel.** (Comptes Rendus, 170. pp. 93–97, Jan. 12, 1920.)—Photometry of distant sources of light is greatly affected by the varying transparency of the air, even during an experiment. The author proposes a differential method of determining this variable factor, analogous to apparatus used by Fabry and Buisson to determine the absorption of liquids and the density of photographs. The suggested form of apparatus is modelled on the spectrophotometer of Lummer-Brodhun. A very powerful light source is required, from 5000 to 10,000 candle-power, with a parabolic reflector to reinforce it if necessary. The beam of light reflected from a distant mirror is compared with one that travels a short path in the air and can be suitably dimmed by measured amounts by means of thick prisms or other contrivances. The distant mirror is of large dimensions (2 m. square is suggested). Correction is necessary for absorption in the prisms, etc., and alternatives are proposed for some of the details. The author thinks the residual absorption by the long path through the air will be easily measurable.

W. W. B.

565. *Optical Images formed by Diffracting Boundary.* **B. C. Das.** (Calcutta Math. Soc., Bull. 10. No. 3. pp. 141–150, 1918–1919.)—Banerji observed [Abs. 417 (1919)] that if a circular aperture placed in front of a lens is illuminated by a point source of light, and if a small screen is placed in the focal plane so as to cut off the entire geometrical cone of rays, a bright image of the source may be traced along the axis behind the screen and for a considerable distance beyond. The author makes the mathematical problem definite by supposing the diffracted rays to pass through an annular opening in the focal plane and concentric with the axis. Then, starting with the known expression in terms of Bessel functions for the disturbance at any point in the focal plane, he develops a mathematical theory which gives a qualitative explanation of the formation of images behind the screen. G. W. DE T.

566. *Theory of Polarisation Prisms.* **H. Schulz.** (Zeits. Instrumentenk. 39. pp. 350–356, Dec., 1919.)—A mathematical paper giving fundamental formulæ for prisms in which the crystal axis is perpendicular to the axis of the prism. [See Abs. 923 (1918).] A. W.

567. *On Large-Angle Diffraction by Apertures with Curvilinear Boundaries.* **S. K. Mitra.** (Phil. Mag. 38. pp. 289–301, Sept., 1919.)—The three cases considered are: (1) Elliptic aperture, (2) semicircular aperture, (3) plane apertures or screens with undulating or corrugated boundaries. The experimental results are then discussed from the theoretical standpoint. L. H. W.

568. *Optical Properties of Crystals in the Infra-Red.* **T. Liebisch** and **H. Rubens.** (Preuss. Akad. Wiss. Berlin, Ber. 48. pp. 876–900, 1919.)—A continuation of previous work [Abs. 721 (1919)]. The substances now dealt with fall into five groups. The first includes the regular crystals zinc blende, lead nitrate, analcim, and various alums. The second group includes opals and chalcedony. The third consists of uniaxal crystals, as tourmaline, zircon, vesuvian, etc. The fourth includes topaz and witherite; and the fifth contains malachite, adularia, and spodumene, belonging to the monoclinic system. Tables and graphs are given of the reflecting powers of the various substances in the region 20μ to 110μ. Transmission data are also given. The results obtained for the dielectric constants are in remarkably good agreement with the values calculated by means of Fresnel's formula from the reflecting power for the long-wave mercury-vapour radiation. Only zircon shows any marked discrepancy in this respect. A. W.

569. *Rotation of Optic Axis of Adularia and Gypsum in Infra-Red.* **H. Rubens.** (Preuss. Akad. Wiss Berlin, Ber 51. pp. 976–989, 1919.)—In the visible spectrum crystals belonging to the monoclinic system show, in general, only small dispersion of the optic axis of symmetry. It was to be expected that this effect would be much more in evidence in the resonance region, in which the refractive index undergoes large variations with the wave-length. The present paper describes experiments which verified the correctness of the above supposition for the long-waved infra-red spectrum. Incidentally, further evidence was obtained in support of the electromagnetic theory of light. [See Abs. 721 (1919) and preceding Abstract.] A. W.

570. *A New Effect of the Rays in Light-sensitive Layers.* II and III. **F. Weigert.** (Deutsch. Phys. Gesell., Verh. 21. pp. 615–622, and pp. 623–631, Oct. 30, 1919.)—The first paper gives an account of some further

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observations with one set of curves to illustrate some of the effects obtained; the second is given up to an explanation of these effects. It is assumed that the light-sensitive element of the colour-sensitive photo-chlorides are either the silver chloride molecule and complex, or else colloidal silver particles. Both these are considered in detail. [See also Abstract 106 (1920).] A. E. G.

571. *A New Non-intermittent Sensitometer.* **L. A. Jones.** (Frank. Inst., J. 189. pp. 303–329, March, 1920. Phot. J. 60. pp. 80–99; Disc., 99–100, March, 1920.)—There are in general three distinct ways in which a photographic plate may be exposed for sensitometric purposes, and sensitometers may conveniently be divided into three classes according to the way in which the required variation of exposure is obtained:—Class A—Intensity scale instrument; Class B—Non-intermittent time scale instruments; Class C—Intermittent time scale instruments. Sensitometers producing graded exposures in all three of these ways have been used by various workers in photographic research. Those of Class B have been but little used. One form proposed by Cowan consists of a plate which is allowed to fall, under the action of gravity, between the light source and the material to be tested. In this plate is cut a series of slots of different lengths, allowing the light to act for various intervals of time upon the areas of sensitive surface behind the several slots. The chief objection to this type is the necessity of applying a correction to compensate for the variable velocity of fall due to gravitational acceleration. Another form proposed by Sebert is much more satisfactory. This consists of a plate-holder, carrying the sensitive material to be exposed, driven at a constant velocity past a metal plate, in which are cut slots of different lengths. On account of the existence of certain discrepancies with rotating-sector instruments which are included in Class C it was decided to replace these by new instruments of the Class B type giving continuous exposures with the intensity constant and the time variable. These instruments, which are described, may be divided into two general types: (1) Those using a thin metal plate in which are cut slots of various lengths, those lengths being proportional to the exposures which it is desired to impress on the sensitive material. Such plates are then moved across the surface of the material to be exposed at a velocity which must be maintained at a precisely uniform rate from the instant at which the exposure starts until it is terminated. (2) In this class the slotted shutter plate, moving at a uniform velocity is replaced by a shutter plate, which is caused to move in a discontinuous manner across the surface of the sensitive material. This motion is produced by the application of a series of impulses, each of which causes the shutter plate to move a fixed distance at an extremely high velocity, the time interval between the application of successive impulses being so adjusted that a series of exposures, increasing by successive powers of either 2, $\sqrt{2}$, or $\sqrt[4]{2}$ as may be desired, is impressed upon the sensitive material. The distance through which the shutter is moved depends upon the size of the area required for measurement. The velocity of movement is made as high as possible in order that all points of a given area shall receive equal exposures. A consideration of the principles involved in these two types of instrument shows that in the case of (1) the precision obtainable depends upon the accuracy with which the various slots in the shutter plate can be cut and upon the uniformity of the velocity with which

that plate can be moved throughout the entire exposure; while in (2) the entire burden of securing precision is thrown upon the mechanism which determines the time intervals between the successive impulses applied to the shutter plates. These instruments are described in detail as is also the timing mechanism, and the exposing machine. From results given it can be seen that a considerable discrepancy exists between the relative values obtained with the non-intermittent sensitometer and those determined by means of the sector-wheel instrument. Further, that the relative values determined by the sector instrument are dependent upon the absolute value of the exposure time taken as a standard. The data presented in this paper are fragmentary and not intended as a treatment of the subject on the intermittency effect, but only to illustrate the difference between the results obtained with sector-wheel and non-intermittent sensitometers. Further work is in progress. A. E. G.

572. *Radiation-Pressure.* **M. N. Saha.** (Astrophys. J. 50. pp. 220–226, Oct., 1919.)—The author, assuming the validity of Schwarzschild's pre-electron theory conclusions [see Abs. 1511 (1909) 1709 (1910)], refers to some of the difficulties which their acceptance would involve, and attempts to avoid them by aid of the quantum theory. He refers to papers by Nicholson [Abs. 1247 (1914)] and by Klotz [Abs. 1247 (1918)], in which they are stated to have confirmed Schwarzschild's conclusions, but Klotz merely quotes an old remark of Arrhenius based upon Schwarzschild, and Nicholson's paper also contains nothing to substantiate the author's statement. G. W. DE T.

573. *Constitution of the Atom and Band Spectra.* **H. Deslandres.** (Comptes Rendus, 169. pp. 1365–1371, Dec. 29, 1919.)—A continuation of previous work [Abs. 1044 and 1203 (1919) and 102 and 220 (1920)]. The author has shown that the quantities K in his general formula are multiples of the fundamental frequency 1062·5. This has been shown to hold very approximately for the various band spectra of nitrogen, carbon, and oxygen. The present paper presents further data for the bands of these substances, and shows that the law is approximately true for all the bands given. It is pointed out that the general formula is itself only a first approximation, and it may be necessary to take account of powers of m, n, and p higher than the second. A. W.

574. *Theory of Band Spectra in relation to Molecular Structure.* **W. Lenz.** (Deutsch. Phys. Gesell., Verh. 21. pp. 632–643, Oct. 30, 1919.)—A theoretical explanation is given of the constants occurring in Heurlinger's formula for band spectra. It is concluded, in particular from a comparison of the theoretical and observed behaviour of bands in a magnetic field, that the N_2 and H_2 molecules have no moment about the axis of symmetry. The many-lined spectra of helium and hydrogen can be accounted for on the theoretical basis advanced, if the assumption is made that the molecules are the emission centres. A theoretical explanation is given of the anomalous polarisation effect observed by Dufour in the case of band lines in the longitudinal Zeeman-effect, and the paper concludes with a short discussion of molecular structure. A. W.

575. *Emission of Luminous Positive Particles by the Alkali Metals at High Temperatures.* **G. A. Hemsalech** and **A. de Gramont.** (Comptes Rendus, 170. pp. 44–47, Jan. 5, 1920.)—The author has previously noted the formation, under the influence of a magnetic field, of helices and luminous spirals due to the trajectories of electrified particles which traverse the space above a plate of graphite covered with carborundum and raised to a high temperature by means of an electric current [see Abs. 253, 368 (1920)]. Further investigation has shown these particles to be derived from impurities contained particularly in the carborundum, and that in the absence of the external magnetic field they constitute the larger part of the bluish vapour. They are derived from compounds of the alkali metals, and consist of positive ions. Research has shown that all the alkali metals may be caused to emit positive particles, and that, for a given temperature, the extension and development of the luminous trajectories varies directly with the atomic weight. Above 2700° C. trajectories due to positive particles emitted by lithium are hardly perceptible, while those due to caesium are very well developed. There appears to be a critical temperature for each of the alkali metals, below which there is no appreciable emission of positive particles.

	At. Wt.	Critical Temperature.
Li	7	2700° C.
Na	23	2550
K	39	2300
Rb	85	2200
Cs	133	1900

The temperatures were measured with an optical pyrometer which has an error of ± 50 deg. towards 2700° C. The critical temperatures are consequently given in round numbers, but the figures are sufficient to show clearly the decrease of the critical temperature with increase of atomic weight. Two possible hypotheses are advanced to account for the expulsion of these positive particles from the atoms or molecules of the alkali metals. A. W.

576. *Arc Spectra of Metals with Low Melting-Point.* **A. de Gramont.** (Comptes Rendus, 170. pp. 31–38, Jan. 5, 1920.)—Comparison spectrograms were obtained for (1) the condensed spark (without self-induction), (2) the d.c. arc, and (3) the carbon arc for each of the metals Zn, Cd, Sn, Pb, Bi, Sb, Mg, and Al. For the direct arc exposures of about 2 seconds were quite sufficient. Typical spectra are reproduced. The results show that in the direct-current arc certain spark lines, considered by Lockyer as "enhanced" lines, are undoubtedly present. Other spark lines also are found in the arc spectra, but the appearance of these lines is not permanent; they are only visible for an instant (appearing at the positive pole) when the arc is struck. They are visible for a slightly longer time with an a.c. arc. Details are given for the different metals dealt with. The results show that arc spectra cannot be regarded as invariable. Notable variations may occur, not only in the intensities of certain lines, but in the appearance or non-appearance of these lines, and these variations are intimately connected with the intensity of the current feeding the arc. A. W

577. *Spectra of Tin, Lead, Antimony, and Bismuth in a Magnetic Field.* **P. A. van der Harst.** (K. Akad. Amsterdam, Proc. 22. 4. pp. 300–312, 1920.)—The Zeeman-effect was measured for 35 lines in the spectrum of tin, 23 in that of lead, 27 antimony lines, and 16 bismuth lines. These results are tabulated and exhibited graphically. The results for the lines measured by Purvis [Abs. 54 (1907)] do not agree well with Purvis' measurements, probably on account of errors in his determinations of field strength. No relation was found between the resolutions of those lines of the four metals for which arrangement in series was proposed, or of those arranged according to the laws of the second kind of Kayser and Runge. The resolutions are pretty regularly distributed between values which amount to about 1·0–1·5 times the normal resolution. As an incidental result it was found that a number of lines given by Schippers for antimony are non-existent. Schippers apparently mistook a number of third-order lines for lines of the second order. These lines range from λ 4370 to λ 3460. A. W.

578. *X-ray Spectrum of Tungsten.* **M. Siegbahn.** (Phys. Zeits. 20. pp. 533–536, Dec. 1, 1919.)—This subject has formed the basis of numerous investigations already published. Its importance is enhanced by the fact that tungsten is the most important antikathode material yet discovered for technical X-ray tubes. After discussing the application of the Coolidge tube in therapy, and the work of Lilienfeld and Seeman, the author describes the aims and methods of the present investigation.

Complete tables are given for the K and L series of the tungsten X-ray spectrum. A. B. W.

579. *X-ray Absorption Frequencies Characteristic of the Chemical Elements.* **W. Duane** and **Kang-Fuh-Hu.** (Phys. Rev. 14. pp. 516–521, Dec., 1919.)—Blake and Duane have already determined the critical absorption wave-lengths associated with the K series of X-rays for most of the chemical elements from bromine (atomic number 25) to cerium (atomic number 58) by measuring the currents in an ionisation chamber attached to an X-ray spectrometer [see Abs. 272 (1918)]. The present work extends the measurements to chemical elements of lower atomic number, as far as manganese (atomic number 25). The results show that the square root of the critical absorption frequency is not quite a linear function of the atomic number. If the velocity v of an electron in an X-ray tube required to produce the radiation be calculated from the equation $\frac{1}{2}\frac{m_0v^2}{(1-v^2/c^2)^{1/2}} = h\nu$ . . . (1), using for ν the critical absorption frequency, it is found that v is a linear function of N, namely $v = v_0(\mathrm{N} - 3/2)$, $v_0 = 0\cdot006783\,c$ . . . (2) (where c is the velocity of light) for all the chemical elements from manganese to cerium. Further, equation (2) gives the critical velocity for the chemical elements as far down as and including magnesium ($\mathrm{N} = 12$), using data obtained from emission spectra. E. A. O.

580. *X-ray Absorption Frequencies Characteristic of the Chemical Elements.* **W. Duane** and **T. Shimizu.** (Phys. Rev. 14. pp. 522–524, Dec., 1919. Paper read before the Am. Phys. Soc., Dec., 1918.)—The

critical absorption wave-lengths associated with the K series of X-rays have been measured for all but two of the known chemical elements from manganese ($N = 25$) to cerium ($N = 58$) [see Abs. 272 and 1163 (1918)]. The object of the present work was to extend the measurements to chemical elements of higher atomic numbers, using the same X-ray spectrometer. The K-critical absorption wave-lengths were measured for eight of the chemical elements from neodymium ($N = 60$) to lead ($N = 82$) both inclusive. The square roots of the vibration frequencies corresponding to their wave-lengths when plotted against the atomic numbers indicate a still greater departure from the straight-line law than do the values previously obtained for elements of lower atomic numbers.

The equation $v = 0 \cdot 00678(N - 3/2)c$, where c is the velocity of light, represents to within $0 \cdot 2\,\%$ the velocity of the electrons in the X-ray tube required to produce the K-emission series of a chemical element of atomic number lower than $N = 58$, if the velocity is calculated by the quantum relation, using the expression for the transverse mass [see preceding Abs.]. The values of v calculated by the same formulæ for elements of atomic numbers higher than 58 fall slightly below those given by the above equation. The greatest variations from the equation amount to a little over $1 \cdot 0\,\%$. E. A. O.

581. *Relation between the Intensity of General X-radiation and the Atomic Number of the Antikathode.* **W. Duane** and **T. Shimizu.** (Phys. Rev. 14. pp. 525–529, Dec., 1919. Paper read before the Am. Phys. Soc., April, 1918.)—The intensity of general X-radiation is known to be approximately proportional to the atomic weight of the element constituting the antikathode provided the other conditions are the same. But since the atomic weights are roughly proportional to the atomic numbers, it may be that the intensity is proportional to the latter instead of the former, considering the important part which atomic number plays in the phenomena of characteristic X-radiation. The object of the present work was to decide this point. Four successive elements, iron, cobalt, nickel, and copper, were used because of the advantage that the atomic weights of cobalt and nickel are in the reversed order of their atomic numbers. An X-ray tube of special type, which enabled the four elements to be brought in turn to the focus of a Coolidge kathode without changing the geometrical relations between the focused point and the measuring apparatus, was excited by a large storage battery of available voltage up to 42,000 volts. The intensity of the rays coming out of the tube which were almost free from characteristic radiations was measured by means of an ionisation chamber and electroscope.

The intensity was found to be proportional to the atomic number, and not to the atomic weight for the above four elements. This was particularly clear, because the observed intensities for cobalt and nickel were in the reversed order of their atomic weights. E. A. O.

RADIO-ACTIVITY.

582. *Origin of Actinium.* **O. Hahn** and **L. Meitner.** (Phys. Zeits. 20. pp. 529–533, Dec. 1, 1919.)—Until quite recently it was considered that actinium was a direct product in the decay of uranium, actinium

and radium forming the primary elements of the two branches in the uranium series. The authors have shown, however, that actinium is not the primary substance in its branch, but that another product, which they have named prot-actinium, separates it from uranium. From an examination by Boltwood of the Ra, Ac, and Ur contents of various minerals, Rutherford deduced that in the disintegration of Ur, 8 % went into the actinium series and 92 % into the radium series. The authors now describe measurements of the relative activities of prot-actinium and uranium in pitchblende, employing different methods of separation. As a result of their analysis they conclude that only 3 ± 0·3 % of uranium branches into the actinium series, and not 8 % as heretofore accepted.

The small value of the percentage now obtained gives strong support to the *derivation of the actinium series from UrY*, and is in agreement with the atomic weights deduced for the individual products of the actinium series, inclusive of actinium-lead. A. B. W.

HEAT.

583. *Variation of the Thermal Conductivity during the Fusion of Metals.* **S. Konno.** (Tôhoku Univ. Sci. Reports, 8. pp. 169–179, Dec., 1919.) —The metals investigated are Sn, Pb, Bi, Zn, Al, and Sb. The thermal conductivities of Sn, Pb, Zn, and Al decrease with rise of temperature up to their respective melting-points. There is a large, abrupt decrease on fusion and a further slight diminution of the conductivity with rise of temperature in the molten state. These changes are similar to those observed by Tsutsumi for the electrical conductivity of the same metals [Abs. 77 (1919)]. Taking Tsutsumi's values for the electrical conductivity the author finds the ratio of the thermal and electrical conductivities to be approximately proportional to the absolute temperature (Lorenz law) up to the temperature of fusion; but the law does not hold in the liquid state. In the case of Bi, the thermal conductivity decreases at first with rise of temperature, but rises slightly as the melting-point is reached. It then increases abruptly on fusion, and diminishes slightly with rise of temperature in the molten state. The behaviour of Sb is very similar to that of Bi, except that on melting there is a slight fall in the conductivity. For Sb and Bi the Lorenz law is only applicable up to about 100° C. L. L.

584. *Variation of Specific Heat of Metals during Fusion.* **I. Iitaka.** (Tôhoku Univ. Sci. Reports, 8. pp. 99–114, Aug., 1919.)—The specimen is heated within its container (silica glass, glass, steel) in a small vertical furnace to the desired temperature (shown by thermo-couple) and then dropped into the water or aniline of the calorimeter, in which it falls on a false bottom of gauze resting on spiral springs. The hot metal (about 9 gm.) sometimes caused explosion of the water (about 650 gm.); aniline gave no trouble; readings of the temperature of the calorimeter (Beckmann thermometer) are taken every 5 seconds for 8 minutes. The specific heat of the solid increased with rising temperature in all cases for Bi, Pb, Sn, Zn, Na and also S; while the substance was fusing, the specific heat further rose in the case of Bi, Zn (maximum change), and Na; in the case of Pb and Sn the specific heat decreased during fusion; sulphur and, further, mercury did not show any change in the specific heat on melting. Once the substance was liquid, the specific heat remained constant at higher temperatures; the specific heat of mercury seemed to decrease very slightly between − 38° and + 250°. The extreme temperature ranges used were − 100° and + 600° C. H. B.

585. *Specific Heat of Air at Ordinary and at Low Temperatures.* **K. Scheel** and **W. Heuse.** (Zeits. Sauerstoff. u. Stickstoff Industrie, 11. pp. 26–29, April, and pp. 33–36, May, 1919. From the Physikal-Techn. Reichsanstalt. Am. Soc. Mech. Eng., J. 42. p. 124, Feb., 1920 Abstract.)—Wiskowski determining the specific heat of air in 1896 at − 77°, − 102°, and − 170° stated c_p to be independent of the temperature, though his own figures suggested an increase of c_p at lower temperatures; he worked by the method of mixtures. The authors applied the continuous flow method of Callendar and Barnes, with two glass calorimeters provided with silvered vacuum jackets and Pt-thermometers, making use of two spherical recipients of 1456 and 1040 cm.^{3} capacity in both cases. Like Swann

(1910), they find the specific heat at 20° higher than Regnault and others had observed. Their values for c_p for dry air, free of CO_2, at 1 atmo. are expressed A, in watt-seconds per gm. deg. C., and B in gm.-cals. at 15° per gm. deg. C., and are at + 20°, − 78°, − 183° : A, 1·009, 1·019, 1·058 ; B, 0·2408, 0·2432, 0·2525 ; accepting the gm.-deg. cal. at 20° = 4·180 watt-second. At atmospheric pressure c_p thus increases by about 5 %, as the temperature is lowered to − 183° ; at 2/3 atmo. the increase was only 3 %. A formula is given for deducing the ratio c_p/c_v, and also the value of c_p at different pressures. [The paper is dated Oct. 1911.] H. B.

586. *Propagation of Flame in Methane-Air Mixtures. I. Horizontal Propagation.* **W. Mason** and **R. V. Wheeler.** (Chem. Soc., J., Trans. 118. pp. 36–47, Jan., 1920.)—Speeds are measured either by the screen-wire method or by photographic analyses, a brass tube with a quartz window being used, and the window being focused by means of a quartz lens on a rapidly revolving film. (A) Ignition at the open end of a tube closed at the other end. The uniform movement is soon accompanied by a vibrating movement travelling first at the same speed, but increasing in amplitude ; when resonance with the gas column between the flame front and the closed end is reached, the amplitude and speed increase greatly, the speed, *e.g.*, from 64 to 278 cm./sec., the amplitude from 3·6 to 6 cm., in a tube 250 cm. long, 5 cm. diam. (B) Ignition at the closed end of a tube open at the other end. There is no uniform movement, but the speed increases as the flame advances. In a steel tube 90 m. long, 30·5 cm. diam., violent vibrations were set up, but the flame was extinguished, probably because in the space between the flame and the closed end, cooling sets in creating a partial vacuum ; the flame indeed leaps forward and backward sometimes. In coal-gas mixtures the higher speed of the detonating wave was actually reached. (C) Ignition at one end of a tube open at both ends. With low-limit methane percentage (5·4) the speed was accelerated throughout the tube length, and there was no extinction. The 10 per cent. methane gave always the greatest speeds ; in a tube, 15·25 m. long, a max. speed of 917 cm./sec. was attained after travelling 14 m. ; the flame seemed to be vibratory. In a tube of 90 m. length the movement became strongly vibratory, but the flame travelled slowly only over the first 15 m., at a speed little exceeding the speed of the uniform period. Thus a long tube open at both ends resembles a shorter tube closed at the far end. In mines, case (C) might be most disastrous in galleries open at both ends. Though the maximum speed momentarily attained in any experiment (60 m.) did not reach that of the detonating wave, detonating conditions were nearly realised in tubes provided with strictures. H. B.

587. *Methods for Computing and Comparing Radiation Data.* **W. W. Coblentz.** (Bureau of Standards, Bull. 15. pp. 617–624, [Sci. Papers, No. 360]; 1920.)—Gives a simple method for computing spectral energy curves, using the Planck radiation formula. In order to facilitate the computations, a table of values of log $(e^x - 1)$ is given. By means of this table, a table of logarithms and a slide rule, the author states that a complete spectral energy curve can be computed in an hour. A chart is given for comparing the thermal radiation constants with similar data obtained directly from theoretical considerations, using Planck's

constant h and data obtained from ionisation-potential, photoelectric and X-ray work. Of course in optical pyrometry and radiation work, the value of c_2 obtained from measurements on black-body radiators must always be used. J. W. T. W.

588. *Heat of Dissociation of Hydrogen according to the Bohr-Debye Model.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Ber. 48. pp. 914–931, 1919.)—The question as to whether the so-called static orbits of the quantum theory are the only ones possible in Nature, or whether they are only distinguished from other orbits by special properties, belongs to the most important problems arising out of the quantum theory; its solution would throw light over a whole series of other difficulties. Every method should therefore be investigated, and the author now examines whether the hydrogen model of Bohr and Debye affords a possibility of calculating the heat of dissociation of hydrogen, since the heat of dissociation of its molecule, at least at sufficiently low temperatures, is simply equal to the excess of energy of the two atoms over the energy of the molecule. This result is naturally dependent on the assumptions made as to the electronic motion in the atom and in the molecule at very low temperatures. If the assumption be made that in all the atoms, as in all the molecules of hydrogen, the electrons execute monoquantic circular motion (on the first theory), the calculated heat of dissociation is about 62,000 cals per mol., while the true value lies in the neighbourhood of 100,000 cals. On the second theory, however, where it is assumed that both in atoms and molecules, all the circular orbits which possess a smaller energy than the monoquantic circular orbit occur in corresponding frequency, then an infinite value is obtained for the heat of dissociation according to classical mechanics, while on relativity mechanics the value 570,000 cals. is given which is certainly too great. This leads the author to a careful investigation of orbits. Rectilinear pendulum motion is therefore considered alongside of circular. Since the second theory appears to promise greater success, the author has only proceeded in this direction in the present paper, assuming that the points corresponding to the different possible electronic orbits are uniformly distributed in the Gibbs' phase. The author also assumes two of the three degrees of freedom to be coherent. While a relatively simple expression is obtained for the energy of the atoms on the above assumptions, yet the corresponding calculation for the molecule is attended with difficulty, and has been approached by an approximation process. Even then the result of 140,000 cals. for the heat of dissociation is still too high, although nearer the actual value. In every case the assumption of circular electronic orbits is found insufficient, and rectilinear pendulum orbits must be associated with them. Section 1 of the paper deals with the heat of dissociation for circular orbits according to the first quantum theory, and Section 2 from the standpoint of the second theory. Section 3 derives the energy of the hydrogen atom on the second theory, and Section 4 the energy of the hydrogen molecule. In Section 5 the heat of dissociation of the hydrogen molecule is calculated on the second quantum theory. H. H. Ho.

589. *Radiometer Theory.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 21. p. 669, Oct. 30, 1919.)—A closer investigation of the theory of radiometer action at high pressures previously given by the author

[Abs. 1066 (1919)] has shown that the theory cannot be maintained, notwithstanding the fact that the agreement between theory and experiment in many cases is very good. The reason for the failure of the theory lies in the fact that it is based on the simplifying assumption of uniform velocity within small ranges, and this assumption is, for heat conduction and associated phenomena, not valid. A new theory is being dealt with by the author and F. Reiche. A. W.

590. *Shape and Regularity of the Vapour-pressure Curve.* **E. Wertheimer.** (Deutsch. Phys. Gesell., Verh. 21. pp. 692–708, Dec. 5, 1919.)—The discrepancies between the pressure curves of various vapours—disregarding those of the fatty acids on account of their varying polymerisations—vanish when the equation $p + Ap^2 = CT^n$ is accepted as an approximation [Abs. 1526 (1919)], where A and C are constants and n has the following values: $n = 7$ for H_2, 10 for O_2 and N_2, 13 for normal vapours, 16 for abnormal vapours. For low saturation values, where the p^2 term may be neglected, the equation embodies Dühring's rule for constant boiling-point differences in homologous series, for which n is constant. The equation further shows that the law of corresponding states can only hold approximately, and that it must fail with different values for n, and when tested at corresponding temperatures (instead of pressures); it comprises also Trouton's rule for the normal heat of vaporisation, the constancy of van der Waals' p at the critical point and Nernst's equation for the calculation of chemical constants. But A and C may vary to a considerable extent without much affecting the agreement with the empirical data. Calculating these constants for benzene, zinc chloride, ethane, water, and other compounds (1/A varying roughly between 2000 and 7000; and 1/C between 10^{26} and 10^{38}) the author finds that the formula shows a good agreement between T and p for pressures above 3 atmos., and again for very small pressures, but not for pressures, *e.g.*, between 3 atmos. and 9·2 mm. (in the case of water). This discrepancy is found also in the case of hydrogen, oxygen, and nitrogen, and is ascribed to the attraction between the molecules, but not discussed in this paper. H. B.

591. *Vapour Pressure of Lead Chloride.* **E. D. Eastman** and **L. H. Duschak.** (Bureau of Mines, Techn. Paper 225. [16 pp.], Washington, 1919.)—Researches undertaken with respect to the chloridising roasting of complex ores. The apparatus resembled that of Wartenberg and of Welch and Duschak. It consists of a test tube, of pyrex glass or silver, 25 cm. long, 2·5 cm. diam., inserted with its closed end in an electric furnace and plugged by a stopper at its projecting end. Inside is a boat, and beyond this a concentric tube enclosing the condenser tube and the thermo-couple tube. The substance is first dried by a current of hot nitrogen or CO_2 (air decomposed the $PbCl_2$), and then further heated. The melting-point of the chloride is found to be 495° C.; 498° is adopted as average of other determinations. The vapour pressure, then 0·137 mm. Hg, rose to 0·218 mm. at 507°, and further to 1·07, 5·3, 26, 112, 228, 754 mm. at 567, 625, 707, 799, 847, 945°. Plotting values of $\log p$ against 1/T, an almost straight line, very slightly curved, was obtained. The heat of vaporisation at the melting-point is 40,600 cals. H. B.

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SOUND.

592. *Hydrodynamics of Cutting (or Edge) Tones.* **E. Schmidtke.** (Ann. d. Physik, 60. 8. pp. 715–733, Dec. 19, 1919.)—These tones arise when a blade-shaped sheet of air or other gas streams out from a slit and meets a more or less sharp-edged wedge. The various factors upon which these tones depend have been investigated by R. Wachsmuth and his pupils. The results are here illustrated experimentally and quantitatively investigated by a tank, slit, and wedge.

A tone first occurs when the edge of the wedge is at a certain minimum distance from the place whence the jet issues. This critical distance a_0 is dependent on the speed U at which the jet issues. The frequency N of the tone falls with increase of the distance a of the edge of the wedge from the mouth of the jet, N being inversely as a. At a certain value a of this distance the frequency of the tone jumps to the octave higher, then again falls with increasing values of a as before. If i is written for the ordinal number of the continuous series of the tone of frequency N which is produced at a distance a by a stream of speed U, then $2aN/iU = \text{constant} = 1$ nearly. The approximate constancy of this quantity is shown in a number of tables. The falling of the frequency with increasing values of a, and its jump to an octave higher, is plotted in graphs. Also three photographs are reproduced showing the turbulent motion of the jet. E. H. B.

593. *Theory of Jet Tones.* **F. Krüger** and **E. Schmidtke.** (Ann. d. Physik, 60. 8. pp. 701–714, Dec. 19, 1919.)—In this paper it is pointed out that the tones given out by air or other gases issuing from a small circular opening or from a slit are analogous to the æolian tones investigated by Strouhal. It is thus concluded that the value of ND/U should be approximately constant, where N is the frequency of the vibration per sec., D the breadth in cm. of the opening through which the gas issues, and U is the speed of the jet in cm./sec. Testing this with five different gases or mixtures (including CO_2, O, and coal gas), using three speeds for each; this constancy in question is nearly confirmed. The mean values are 0·049, 0·046, 0·045, 0·042, and 0·036, the last being for a mixture of air and coal gas of specific gravity 0·716, the first being for CO_2 of sp. gr. 1·525. The paper includes two photographs showing the turbulent state of the jet. E. H. B.

594. *Resonant Reflection of Sound from a Perforated Wall.* **Rayleigh.** (Phil. Mag. 39. pp. 225–233, Feb., 1920.)—This is a mathematical paper and follows the same lines as in the late author's *Theory of Sound*, § 351, 1896, where the effect of porosity of walls on the reflecting power for sound is considered. In the complete absence of dissipative influences, what is not transmitted must be reflected, whatever may be the irregularities in the structure of the wall. In the paragraph referred to, the dissipation regarded is that due to gaseous viscosity and heat conduction, both of which causes act with exaggerated power in narrow channels. For the present purpose it seems sufficient to employ a simpler law of dissipation. Somewhat complicated general expressions are obtained for the reflected wave. But these reduce so as to satisfy the various checks applied. It is also shown that within certain limiting conditions it may be possible to arrange that no reflection shall occur. The analogy to an optical case is also pointed out. E. H. B.

595. *Combination Tones and Röntgen Rays.* **A. Pflüger.** (Deutsch. Phys. Gesell., Verh. 21. p. 668, Oct. 30, 1919.)—Puts forward the idea that by two Röhtgen rays of near frequencies it might be possible to obtain a "difference tone" in the visible region of the spectrum. E. H. B.

596. *Determination of Frequencies, Acoustical and Electrical, by the Method of Beats.* **R. Weller.** (Jahrb. d. Drahtl. Tele. 14. pp. 599–608, Nov., 1919.)—The frequency being given by $N=1\div 2\pi\sqrt{(CL)}$ or $N^2C=1\div 4\pi^2L$; if C be varied by dC while L is kept constant we obtain $N=-2C.dN/dC$. Thus dN being found by beats, N is calculated. Details of the valve circuits are shown in diagrams and the sources of error are discussed. E. H. B.

597. *Existence of Neighbouring Tone Spectra by Beat Reception.* **M. Wien.** (Jahrb. d. Drahtl. Tele. 14. pp. 608–619, Nov., 1919.)—It is shown that the neighbouring tone spectra by beat reception may be theoretically explained by overtones of transmitter and receiver as well as by combination tones. A number of diagrams illustrate the circuits under discussion. E. H. B.

598. *Temperature Change of Transversely-vibrating Wires.* **H. Kost.** (Deutsch. Phys. Gesell., Verh. 21. pp. 774–778, Dec. 30, 1919.)—The mean temperature changes of wires while vibrating with various amplitudes in Melde's experiment are here investigated. [See Abs. 1293 (1915).] E. H. B.

599. *Sound Ranging.* **A. Trowbridge.** (Frank. Inst., J. 189. pp. 133–146, Feb., 1920.)—It is shown that, when the difference of time between reception of the sound from a gun at two places is known, the gun must lie on a particular hyperbola. If, however, the instants of reception are known at three or more places the gun may be located. This process is facilitated by a plotting board which is described in detail by aid of a diagram. E. H. B.

600. *Upper Limit of Unpleasant Beats.* **N. Chatterjee.** (Nature, 104. p. 708, Feb. 26, 1920.)—The author, following up the view of Helmholtz gives a formula for the upper limit of the frequency of beats at which their roughness just vanished. This is $B=N/(0\cdot 7+u+i)$, in which N is the frequency of the lower of the two notes, u is the member of the musical scale containing N and beginning with 32 per sec. on the fundamental of the first scale, and i shows where N stands in its octave. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

601. *Scattering of Plane Electric Waves by Spheres.* **T. J. I'A. Bromwich.** (Roy. Soc., Phil. Trans. 220. pp. 175–206, Feb. 2, 1920.)—The author, in an analysis greatly simplified by the use of spherical polar coordinates, obtains the general solution of the problem of finding the scattered waves when a plane S.H. wave strikes a sphere, and applies the solution to the case of a small sphere. The case of a large sphere is dealt with by applying to the general solution the method of approximation devised by H. M. Macdonald for dealing with waves incident from a Hertzian oscillator on a conducting sphere [Abs. 600 (1910)]. Rayleigh has shown [Sci. Papers, 1. pp. 522–536] that in the case of small obstacles of any shape, with constants K, μ, differing little from unity, the electric and magnetic forces in the scattered waves are at right angles to each other, and to the radius in the case of spheres, and their magnitudes are related in the same manner as in a plane wave. This conclusion is here shown to hold good for spheres of any size. G. W. DE T.

602. *Electrical Density of a Plane-Sphere System.* **F. Defourneaux.** (J. de Physique, 9. pp. 165–188, May, 1920.)—A mathematical article dealing with the calculation of the electrical density of a plane-sphere system. The method adopted essentially consists in supposing electrical masses distributed along the perpendicular to the plane from the centre of the sphere and opposite in sign to that of the sphere or of the plane. Each of these imaginary masses produces in the sphere and in the plane a certain non-uniform electrical distribution which gives rise in each point to an electrical density; this latter can be calculated by elementary formulæ. Curves of the electrical density both on the sphere and on the plane for different cases, and tables for facilitating calculations are given. E. B.

603. *Current and Equivalent Shell.* **S. Ray.** (Phil. Mag. 39. pp. 134–145, Jan., 1920.)—Starting with a circular electric current and an equivalent magnetic shell contained by two nearly adjacent equipotential surfaces having the circle as common intersection, the author develops the thesis that a system of electric currents and their equivalent magnetic shells may be regarded alternatively as consisting of a system of magnetic currents and electric shells, the electron being the fundamental unit in the former case and the magnetic pole in the latter. G. W. DE T.

604. *The Spheroidal Electron.* **A. Anderson.** (Phil. Mag. 39. pp. 175–176, Feb., 1920.)—The paper gives general expressions for the momentum and the energy of a spheroidal electron with semiaxes a, b, the former being in the direction of motion, for $\beta b \gtrless a$, respectively, where $\beta=(1-v^2/c^2)^{-1/2}$. For $\beta b=a$, the case of the Lorentz electron, both pairs of expressions lead to the same result. For $a=b$, the case of the Abraham electron, only the first pair are applicable, since $\beta b>a$. The author suggests that it would be of interest, but possibly involving tedious mathematical work, to determine the value of b/a for which the theoretical value of e/M would agree most closely with the experimental results. He also notes that for $b/a \doteqdot 0$, the corresponding value of the momentum $M \doteqdot c^2\beta v/16ac^2$, *i.e.*, the ether momentum associated with an electron whose shape is a plane circular disc moving uniformly perpendicularly to its plane is $3\pi/8$ times the momentum associated with the Lorentz electron moving with equal velocity v. The ratio of its transverse mass to its mass when $v=0$ is the same as for the Lorentz electron, so the experimental results could not decide between them. In the case of a very elongated prolate spheroid moving in the direction of its axis of symmetry, both momentum and energy become very great. G. W. DE T.

605. *Spray-Electricity and Waterfall-Electricity.* **H. Zwaardemaker** and **F. Hogewind.** (K. Akad. Amsterdam, Proc. 22. 5. pp. 429-437, 1920.)—By spray-electricity is meant that which arises when water is broken up by air currents; by waterfall-electricity is meant that which is produced when water strikes an air-liquid or air-solid surface. Differences are found in the action of these two cases. Thus (1) pure water yields no perceptible spray charge, but it yields a large positive charge on impact in the waterfall effect; (2) odorous matters render spray charges excessive; in waterfall-electricity they produce sometimes positive, sometimes negative, charges.

The authors use substantially Lenard's form of apparatus. A metal cylinder is provided with a fine glass tube below. A jet of water issuing under pressure falls on a zinc plate in a lower vessel. The whole is insulated and joined by a wire to an electroscope.

Various substances introduced into the falling water have marked influence on the resulting charges. The materials used are grouped into: (*a*) *odorous*—phenol, indol, camphor, acetic acid, etc.; (*b*) *sweet*—saccharose, glucose, glycerine, etc.; (*c*) *bitter*—quinine, quinine sulphate, etc.; (*d*) *colloidal bitters*—quassia, etc.; (*e*) *salts*; (*f*) *acids*; (*g*) *bases*; (*h*) *colloids*; (*i*) *alkaloids*, and others. In all, some 85 materials were used successively with the issuing water. The salts, acids, bases, and bitters produce in general *negative* charges. The other materials produce in general *positive* charges.

The authors consider that Lenard's theory is not complete enough to cover all the results they obtain. P. E. S.

DISCHARGE AND OSCILLATIONS.

606. *Pressure upon the Poles of the Electric Arc.* **I. W. G. Duffield, T. H. Burnham,** and **A. H. Davies. II. W. G. Duffield.** (Roy. Soc., Phil. Trans. 220, pp. 109-136, Dec. 22, 1919.)—In a carbon arc it is found that there is a mechanical pressure upon each electrode which tends to separate them. This pressure is measured by fixing one carbon rod of the arc at right angles to a copper rod suspended by a torsion fibre, striking the arc between this pole and another fixed carbon rod and observing the torque required to keep the movable pole in its zero position. The observed couple is due to (1) a pressure on the pole due to forces in the arc including convection currents, electrostatic effects, etc., called the total pressure; (2) interaction between the currents in the suspended part and the earth's magnetic field; (3) the "electromagnetic effect" between the currents in the suspended part and the rest of the circuit. The pressure is measured both for alternating and direct current, the former automatically eliminating (2) above. The electromagnetic effect and convection-current effects are eliminated or estimated by various dispositions of the poles of the arc and special experiments, for details of which the original paper must be consulted. The variation of total pressure with arc-length for constant current is determined. For the kathode it shows a rapid drop as the arc-length is increased from very small values and for longer arcs approaches a constant value usually reached at about 10 mm. arc-length. The total pressure on the anode also shows a drop as the length is increased from small values, approaching constancy for arcs longer than about 3 mm., but in one series of measurements a minimum value is suggested for arcs carrying small currents at about 3 mm. Whether anode pressure or kathode pressure is greater depends upon the arc length, but for long arcs there is little doubt that anode pressure preponderates. For constant arc-length the pressure varies with the current. The total pressure rises more rapidly than the first power of the current but not as rapidly as the second power. When these values are corrected for convection currents it is probable that the curve of pressure and current is linear and passes through the origin. For an arc 6 mm. long carrying a current of 10 amps. the forces on kathode and anode are 2·18 and 2·10 dynes respectively. The hydrostatic pressure near the anode of an arc, measured by Dewar (who gives no data respecting current and arc-length), is about 100 times the total pressure measured here.

II. This second part deals with the origin of the pressure. The reaction on the poles caused by radiometer action, produced by increased velocity of gas molecules after impact with the hot electrodes, and by evaporation of carbon atoms is first considered. It does not appear from the calculations that the reaction can be accounted for on any simple assumption which regards its cause as molecular or atomic projection from the electrodes. It is calculated that, for the particles projected from the kathode, $e/m = \frac{1}{2}v(C/p)^2$, where e/m is the ratio of the charge carried by a particle to its mass, c the current, p the pressure on the pole, v the potential drop across the pole face. Taking the value of v given by Duddell, inserting the values of c and p found in Part I it is found that the evidence is in favour of the projection responsible for the reaction being electronic rather than molecular. If it is assumed that the current in the neighbourhood of the kathode is carried half by positively-charged atoms and half by electrons, the value of e/m approximates very closely to that for the electron. Such electronic projection is to be expected through thermionic emission and photo-electric action in the arc. The view of the mechanism of the arc which is most favoured by the results is that an oxygen atom arrives at the kathode with two positive electronic charges and that uncharged CO is formed which removes two of the four electrons associated with the departure of each C-atom from the pole. The other two electrons are liberated and the expulsion of such electrons involves the recoil here measured. This view attributes the fall of potential across the negative pole face to electronic projection, contrary to the theory which regards the electric force as responsible for the extraction of the electron.

The author has previously described a series of spectrum lines (" polar lines ") which make their appearance near the poles of an iron arc and has suggested something in the nature of an explosion upon the surface of the pole to account for the potential drop which appears to be associated with them. It is now suggested that the explosion results in the liberation of a high-speed electron and that the polar line is due to the particular type of vibration which is set up when the electron is expelled from the atom. Evidence for the photoelectric origin of the polar lines is discussed, the experiments described favouring the view that electrons are ejected from the atoms themselves, rather than from the pole considered as a whole. A similar recoil upon the suspended kathode within a highly exhausted vacuum tube is also observed, but the mechanical effect has not yet been measured. T. H.

607. *Quantum Theory of Electric Discharge.* **D. N. Mallik** and **A. B. Das.** (Phil. Mag. 39. pp. 233–238, Feb., 1920. Paper read before the All India Science Congress, 1919.)—On the quantum theory, the energy of a source of radiation varies in a discontinuous manner by equal quanta. If this is to be accepted, since electrons give out radiation when their velocity is changed, the quantum theory would seem to suggest that these changes are effected by a series of jerks, that is, in other words the changes involved are due to impulses only. Moreover, since a material atom is known to be made up of corpuscles and positive ions, having configurations satisfying conditions of dynamical stability, under their mutual attractions and repulsions it is necessary to admit that they are revolving doublets or higher complexities. In any case a variation of energy in a discontinuous manner is consistent with many well-known phenomena. The present paper applies the quantum hypothesis to the electric discharge in a vacuum tube and attempts to interpret its behaviour in terms of this theory. E. H. B.

608. *Anode Discharges.* **E. Goldstein.** (Deutsch Phys. Gesell., Verh. 21. pp. 559–571, Sept. 30, 1919.)—This forms a continuation of the experiments described in a previous paper [see Abs. 1539 (1919)] and is again fully illustrated. It is now concluded that the induced thread of light, which appears when a straight glass rod of 1 to 2 mm. thickness is placed opposite the middle of the anode surface and at right angles to its plane, consists of negative particles and that these particles are small ions. A. E. G.

609. *Violet Colouration of X-ray Bulbs.* **S. Masuzawa** and **J. T. Liu.** (Phys. Math. Soc. Japan, Proc. 2. pp. 2–6, Jan., 1920.)—With continued use the ordinary X-ray bulb becomes blackened on its inner surface and the glass assumes a violet colour. It is believed by some authorities that the disintegration or "sputtering" and also the volatilisation of the antikathode are the main causes of the blackening, whereas the violet colouration is due to the ultramicroscopic particles of oxidised metal. The violet colour is most pronounced on the front side of the antikathode. α-rays affect glass as well as quartz in the same way, though to a greater depth. Also, kathode rays produce a similar colouration in a number of crystals. On the other hand ultra-violet and solar radiation may produce the violet colour in some kinds of glass. Possibly these actions are of allied nature in all cases, being destroyed by heating.

The experiments here described are undertaken to investigate the manner in which the violet colour of X-ray bulbs is destroyed by heating. Owing to the many difficulties encountered qualitative results only have been obtained. The method adopted is as follows: The piece of the coloured glass is etched by a solution of hydrofluoric acid on its inner surface to remove the black coating and then put into an electric furnace side by side with a similar piece of colourless glass, obtained by heating in a gas furnace the piece cut from the less coloured part of the same bulb, the latter serving as a control for comparing the absorption due to colouration alone. In some experiments the temperature is raised as rapidly as possible until it attains a desired constant value. In the other sets, it is raised gradually at nearly uniform rate. The change in absorption of light with different wave-lengths is observed by means of a König-Marten's spectrophotometer, during the entire course of the heating. For source of light, a 100-c.p. Nernst lamp is used of which nearly homogeneous light of wave-lengths 4923, 5460, 5774, and 6156 Å.U. is adopted. In one set of experiments the temperature is raised rapidly up to 260° C. and then kept constant. In this case the absorption began to diminish near 230° C. The rate of diminution was remarkable at first but soon became slow. In another experiment, the temperature is raised to 350° C. in a similar way. Though in this case the absorption is remarkably reduced before the final temperature is reached, still a slow diminution is observed when the temperature is kept constant for a long time. In a third experiment the temperature is raised to 440° C. and then kept constant. From a diagram given it can be seen that the absorption in these cases diminishes very rapidly at first and then slowly, the course of the curve being nearly exponential. It can also be seen that in the final state the absorption continually increases with the wave-length, showing that the maximum of absorption in the visible region has disappeared. In the other series of experiments the temperature is raised gradually at nearly uniform rates. The results are shown in a second diagram. The absorption begins to diminish between 200° and 250° C. The rate of diminution increases as the temperature increases, becomes a maximum near 470° C., and decreases again with further rise of temperature. The relation between wave-length and absorption is similar to the former experiments.

It is assumed that the violet colour is due to a sort of ultramicroscopic particles in the glass and also that these particles have undergone some change of structure by the action of X-rays so that they show a selective absorption of light. When heated, the mechanism is destroyed and reverts to the initial state showing no selective absorption in the visible parts of the spectrum. The selective absorption is assumed to depend on the number of particles transformed and equations are obtained for the two sets of curves given.

No apparent change of colour takes place in the violet-coloured glass by immersing it in liquid air. A. E. G.

610. *Glow-Discharge Tubes.* **F. Schröter.** (Elekt. Zeits. 40. pp. 685–687, Dec. 25, 1919.)—The tubes here considered have no incandescent kathode, as in the case of three-electrode valves of the usual type; but have only two electrodes, the bulb containing helium, argon or neon at a pressure of the order of 0·1 mm. of mercury. If a certain p.d. E be applied to the electrodes, a glow discharge will take place, the value of E depending on the distance apart of the electrodes. Such tubes can be employed for various purposes. Rectification of alternating current is possible to an extent depending particularly on the effective surface area of the two electrodes. The efficiency of rectification depends also on the gas filling the bulb, and is the higher the more electro-positive the kathode metal is. An arrangement is also described in which a discharge tube of this kind acts as a sort of relay. Theory of the action of this arrangement is also given. [See Abs. 243B (1916).] A. W.

611. *Dynamic Characteristics of Audion Valves.* **A. Blondel.** (Comptes Rendus, 169. pp. 1377–1382, Dec. 29, 1919.)—In previous papers [Abs. 143 (1920)] the author has shown how the dynamic characteristics of audions can be derived from the ordinary characteristics, and how these dynamic characteristics may be employed in the study of the oscillations when the valves are employed as generators. In the present paper the method is applied to the cases where an alternating e.m.f. is applied in the anode circuit or in the grid circuit of the valve. A. W.

612. *Experiments in which Two Neighbouring Maintained Oscillatory Circuits affect a Resonating Circuit.* **J. H. Vincent.** (Phys. Soc., Proc. 32. pp. 84–91; Disc., 91, Feb., 1920. Radio Rev. 1. pp. 285–287, March, 1920. Abstract.)—Two self-maintained oscillating valve-circuits, one of which is provided with an adjustable subsidiary condenser of small capacity, each cause oscillations in a third resonating circuit. The third circuit has its condenser plates connected through a crystal detector and galvanometer. When the maintained circuits are in exact unison a very small change in the capacity of the subsidiary condenser causes the galvanometer needle to move through a large angle. In the tuning process, variations of capacity of 1 part in 25,000 could be detected.

Detection of small changes of frequency.—The method provides a means of observing such small changes previously studied by the method of beats. **O. W. Richardson** drew attention to the similarity of the galvanometer curves to those representing anomalous dispersion in the neighbourhood of an absorption band, and suggested that the explanation was probably the same in the two cases. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

613. *Comparison of Resistance Standards.* **H. Conrad.** (Elektrot. u. Maschinenbau, 37. pp. 522–526, Nov. 16, 1919.)—Gives the results of comparisons carried out between the standards of the Normaleichungskommission of Vienna and the degree to which these have maintained their values as compared with the standards at the Physikalisch-Technische Reichsanstalt. The period covered is from 1894 and it is found that the values have suffered very slight variations, except in the case of the heavy-current resistances where the variation has been as much as 2 parts in 10,000. J. W. T. W.

614. *Variation of Electrical Conductivity of Oils and Waxes.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 1. pp. 320–326, Nov.–Dec., 1919.)—The author studies the variation of electrical conductivity during crystallisation or solidification of melted fats or waxes. Simultaneous observations of temperature and conductivity are made at intervals while the test material passes from the liquid to the solid state. The current through the substance is measured by the rate of discharge of a condenser connected to one of a pair of electrodes immersed in the substance. Temperature is measured by a mercury thermometer which, covered with copper foil, serves as the other electrode.

With all the substances examined, conductivity decreases gradually with the temperature of the liquid. During crystallisation the temperature remains constant (rises with Japan tallow), while the rate of decrease of conductivity becomes small but does not vanish. Conductivity, therefore, depends on the state of crystallisation as well as on temperature. Most of the natural fats and waxes have some free acids, organic or inorganic. The acid components or impurities may be in a state of electrolytic dissociation in the liquid state of the substance and the discharge current partly a convection current of the electrolytic ions. When the substance has solidified and cooled to ordinary temperatures there is reason to believe a small conductivity remains and motion of free electrons may be considered to exist to a very small extent. T. H.

615. *Dielectric Polarisation.* **M. Eguchi.** (Phys. Math. Soc. Japan, Proc. 1. pp. 326–331, Nov.–Dec., 1919.)—In a previous paper [see preceding Abs.] it was found that some substances have a finite electrical conductivity in the melted state, but that the conductivity gradually diminished as crystallisation occurs, and they become nearly perfect insulators in the solid state. It should be possible to obtain a "permanently polarised dielectric" by allowing some kind of wax to solidify in a strong electric field. In the present work, a mixture of equal parts of beeswax and resin forms the dielectric and is contained in a shallow copper dish. A plate is arranged to touch the surface of the melted substance and plate and dish are connected to the poles of an influence machine. When in the liquid state a current flows through the substance, becoming insensible when the solid state has been reached. When completely solid and cooled down the dielectric is "permanently" polarised. The plate of this electrophorus is removed, temporarily earthed, re-insulated, and replaced on the surface of the medium; its potential is then measured by an electrometer. The residual charge gives a potential of about 1000 volts by this method. Except when under test, the plate is connected to the dish, the connection being analogous to the keeper of a permanent magnet.

A series of experiments is described; the surface of the insulator is exposed to soft X-radiation for one minute and the surface charge temporarily destroyed; the potential is measured, as above, at intervals and curves are given showing the recovery of charge of the electrophorus plate. Four exposures to X-rays were made in a period of 20 days. The recovery of potential each time follows a law $v - v_1 = (v_0 - v_1)e^{-\lambda t}$ where, v, v_0 are potentials at times t and 0; v_1 is the final steady potential, λ a constant. This holds except that for a few minutes after the exposure the calculated voltage is greater than that observed. The charged condition of the insulator remains practically unchanged and "it is evident that the source of the charge is the permanent polarisation of the internal portion of the insulator, utterly different from anything like surface electrification." T. H.

616. *Dielectric Residual Charge.* **H. Tsutsumi** and **H. Saegusa.** (Tôhoku Univ. Sci. Reports, 8. pp 207–213, Dec., 1919.)—Describes an investigation of the amount of residual charge in various dielectrics (mica, ebonite, paraffin paper, glass, and celluloid) in the form of thin sheets. The investigation was threefold. In determining the relation between residual charge and accumulation time-interval after the condenser had been earthed (time of charge, t_1, 60 secs.; time of earthing, t_2, 10 secs.; voltage 50), it was found that good insulators (mica, paraffin paper, ebonite, and glass), in a perfectly dried state, showed an increase of residual charge as the discharging interval t_2 was shortened, and that the accumulation corresponding to a definite discharging interval tended to an asymptotic value. In the case of imperfect insulators such as celluloid, the accumulation reached a maximum at a certain time, t_3, after which it decreased. This maximum increased in magnitude and was attained sooner as t_2 decreased. The relation between residual charge and discharging interval, t_2 was also found for $t_1=60$ secs., $t_3=60$ secs., voltage 50. As t_2 increased, the liberation of residual charge decreased rapidly. For mica and paraffin paper this decrease was logarithmic; in the case of ebonite the residual charge decreased more rapidly as t_2 increased, tending to an asymptotic value. The amount of residual charge increased approximately according to an exponential law with increase of t, while it was found that residual charge and applied potential were proportional up to 60 volts. The results obtained are given in tabular from and are also shown graphically in the paper.

J. W. T. W.

617. *Electronic and Light Emission from Short Tungsten Filaments.* **G. Stead.** (Inst. El. Eng., J. 58. pp. 107–117, Jan., 1920.)—Describes an investigation of the effect of end-cooling on the candle-power and emission of a tungsten filament. Experiments were made with filaments of pure tungsten and with those containing 1% of thoria. The relations between filament current, diameter, volts per cm., candle-power per cm., and electronic emission per cm. have been determined by Langmuir [see Abs. No. 578 (1916)], and the author has, by means of an optical pyrometer mounted on a cathetometer, measured the distribution of temperature along a filament in the neighbourhood of a lead. This was done for a series of max. temperatures, and it is shown in the paper how to calculate from these observations the distribution of temperature along a tungsten filament of any diameter. In this way, end-correction curves have been obtained for voltage, electron emission, etc. Methods are described for the design of filaments to give any desired electron emission for a given overall voltage. The curves given enable similar methods to be developed for the design of filaments to satisfy a variety of other conditions, *e.g.*, filaments in which a specified filament current will produce a given emission.

J. W. T. W.

618. *Measurement of Very Small Capacities and Inductances.* **L. Pungs** and **G. Preuner.** (Phys. Zeits. 20. pp. 543–545, Dec. 1, 1919.)—The arrangement described comprises three oscillatory systems. Two of these are high-frequency valve generators with back-coupling, and the third a valve generator giving audible notes of frequency about 1000 per sec. The frequency of generator I is of the order of 10^5 to 10^6 per sec. When using the apparatus, generator II is kept constant and any capacities to be compared are introduced as required in the oscillatory circuit of generator I, while II is adjusted to have a frequency differing by about 1000 from that of I. A circuit comprising a detector, blocking condenser, and two small coils is very loosely coupled to generators I and II. A telephone is shunted across the condenser and is also affected by the note given out by generator III. Thus, if the frequency of III

is equal to the difference in frequency of I and II, no beats will be heard in the telephone, but the slightest variation of capacity or inductance in I will result in beats being heard. Theory is given showing how measurements of capacity and inductance can be effected with the apparatus. A. W.

619. *Measurement of Very Small Capacity Variations.* **J. Herweg.** (Deutsch. Phys. Gesell., Verh. 21. pp. 572–577, Sept. 30, 1919.)—The method consists essentially of including the capacity, whose variation is to be measured, in one of two valve circuits arranged for self-oscillation. The two circuits are coupled together, and a heterodyne note of (say) frequency 1000 per sec. is obtained in telephones included in one of the circuits. This note is compared with that of a tuning-fork of the same frequency. Any small variation of capacity is then indicated by beats obtained between the note given by the tuning-fork and the note heard in the telephones. Various precautions are necessary. The whole apparatus is enclosed in an earthed tin box; the note of the telephones is observed by means of a tube attached to them and passing out through the box to the ear; and the fine regulation of the telephone note is effected by a handle, passing out through the box, attached to the small variable condenser of one of the oscillatory circuits. Attention has also to be paid to keeping all the coils, insulation, and resistances dry. This is effected by means of calcium chloride. A. W.

620. *Direction of E.M.F. and the Right-hand Rule.* **W. M. Thornton.** (Electrician, 84. p. 200, Feb. 20, 1920.)—The author derives the rule for the direction of e.m.f. in a conductor moving in a magnetic field from the motion of a positive or negative electric charge through the field. G. W. DE T.

ALTERNATING CURRENTS AND MAGNETISM.

621. *Magnetic Susceptibilities of Low Order.* **E. Wilson.** (Roy. Soc., Proc. 96. pp. 429–455, Feb. 3, 1920. Engineering, 119. pp. 316–317, March 5, 1920.)—An instrument is described which is a modified form of Curie's magnetic balance. The core of the magnetic circuit is formed from a ring of stalloy with an air-gap 1·5 cm. wide. The test specimen is suspended, within the gap, from one end of a torsion balance, the mechanical force on it being balanced against the force of torsion. In exploring the field within the air-gap, a suspended system was employed which consisted of two horizontal parallel wires, one above the other, joined at one side by a vertical Pt wire which could be set within the air space and a current passed through it. By displacing the electromagnet at right angles to the plane of the ring, a series of observations was obtained from which it was possible to determine graphically the variation of magnetic force from the centre of the air space outwards. The constant of the instrument was determined by testing various substances whose susceptibilities had been measured by other methods. Powdered rocks were compared with the solid, and fair agreement was obtained. Values are given for the susceptibilities of a large number of varieties of mica; in certain cases, in any direction parallel with the laminæ the susceptibility may be more than fifty times that in a direction perpendicular to the laminæ. In the case of aluminium, the susceptibility is diminished by alloying with cobalt. The instrument can be

used to determine rapidly the relative amounts of ferrous iron in different specimens of glass. Data are also given for tourmaline. [See also Abs. 1097 and 1559 (1919).] G. E. A.

622. *Electroplated Iron in High-frequency Fields.* **G. Preuner** and **L. Pungs.** (Deutsch. Phys. Gesell., Verh. 21. pp. 594–602, Sept. 30, 1919.)—Experiments are described on the effect of giving iron fittings, used in wireless installations, an electrolytic deposit of copper or zinc. Where angle iron and sheet iron are used in the bare state, an increased damping is observed compared with the effects obtained when the iron parts are covered with thin copper. The electro-deposition of a layer of copper of from 0·03 to 0·04 mm. thickness on iron fittings in high-frequency fields is found sufficient to shield the iron, and the losses are then nearly the same as if solid copper fittings were used. If zinc is used instead of copper, the thickness of the deposit must be of the order of 0·1 mm. to provide an effective covering for the iron. A. W.

623. *Absolute Retardation in the Kerr Effect.* **Pauthenier.** (Comptes Rendus, 170. pp. 101–103, Jan. 12, 1920.)—The author points out that previous investigators have failed to eliminate the effect of electrostriction in studying the Kerr phenomenon. By a new experimental arrangement in which the condenser is rapidly charged and the illumination intermittent the effect of electrostriction is eliminated. Preliminary experiments using nitrobenzine show that the vibrations perpendicular to the electric field are accelerated and those parallel to the field are retarded. The retardation is greater than the acceleration. L. L.

624. *Magnetic Susceptibilities of Hydrogen and some other Gases. Gaseous CO_2 shown to be Diamagnetic.* **T. Soné.** (Tôhoku Univ. Sci. Reports, 8. pp. 115–167, Dec., 1919. Phil. Mag. 39. pp. 305–350, March, 1920.)—The relative magnetic susceptibilities of various gases have been measured, the susceptibility of pure water being taken as $-0{\cdot}720\times10^{-6}$. In the measurements made on air, redistilled water was used as the standard substance, whilst for the other gases, air at the ordinary or at higher pressure was taken for comparison. The specific susceptibility of gases is assumed to be independent of the pressure for the range 1–68 atmos. employed, this assumption being found to hold within the limits of accuracy of the experimental results. The values obtained for the specific susceptibilities at 20° (X) and for the volume susceptibilities at 0° and 760 mm. (χ) are as follows :—

	$X\times10^6$.	$\chi\times10^6$.
Air	$+\ 23{\cdot}8_5$	$+0{\cdot}308_4$
Oxygen	$+104{\cdot}0_1$	$+0{\cdot}148_8$
Carbon dioxide............	$-\ 0{\cdot}42_3$	$-0{\cdot}00083_6$
Nitrogen (chemically pure)	$-\ 0{\cdot}26_5$	$-0{\cdot}00033_1$
Nitrogen (atmospheric)	$-\ 0{\cdot}36_0$	$-0{\cdot}00045_2$
Argon	$-\ 5{\cdot}8_6$	$-0{\cdot}010_4$
Hydrogen	$-\ 1{\cdot}98_2$	$-0{\cdot}000178_1$

The fact that the susceptibility of air coincides closely with that calculated from the values of its constituents shows that these values are accurate and also that the additive law holds for the susceptibility of a gas mixture. Hence, in deducing the susceptibility of air from that of oxygen, it is inadmissible to neglect the magnetism of nitrogen and argon, which together contribute about 1% to the total for air. The value of the diamagnetic susceptibility of nitrogen derived indirectly by Pascal [Abs. No. 281 (1910)], is 5% greater than that obtained directly by the author. The value given for argon in the above table is an indirect result, but agrees well with the value, $-6\cdot1\times10^{-6}$, given by Tänzler's direct measurement [Abs. 478 (1908)]. Gaseous CO_2, hitherto believed to be paramagnetic, is now shown to be diamagnetic; further, the specific susceptibilities of the solid and gas have almost the same value. The hydrogen measured contained not more than 1 vol. of oxygen in 150,000 vols., and the value now obtained for its susceptibility is approached most nearly by that of Pascal (*loc. cit.*) calculated from the susceptibilities of organic compounds and by that of Onnes and Perrier [Abs. 1232 (1911)], obtained by not very accurate measurements on liquid hydrogen.

The experimental results obtained are discussed in the light of the electron theory, it being shown that monatomic and diatomic gases are all diamagnetic and that their susceptibilities may be calculated provided that the models of the molecules are known; this conclusion is in general agreement with the observed facts. The important exception to this rule, namely, the paramagnetism of the diatomic oxygen, is explainable by the assumption of particular conditions. Polyatomic gases are paramagnetic or diamagnetic according to their different characters. In this discussion the molecules are assumed to be rigid, and no account is taken of the Langevin diamagnetism, but introduction of this small diamagnetism does not materially alter the conclusions reached.

T. H. P.

625. *Terrestrial Magnetic Variations and their Connection with Solar Emissions which are Absorbed in the Earth's Outer Atmosphere.* **S. Chapman.** (Cambridge Phil. Soc., Trans. 22. pp. 341–359, Nov., 1919.)—The author deals with non-secular changes of the earth's magnetism, distinguishing between *regular diurnal variations*, and *disturbance variations*, including what he terms *disturbance diurnal variations*. The first of these is studied conveniently in the data from international "quiet" days, while the disturbance phenomena are manifest in those from magnetic storms. The regular effects of disturbance depend on latitude and on local time, and are separated by analysis into those dependent on latitude only, depending on "storm" time, measured from the sudden commencement of the magnetic storm, and others depending also on local time constituting disturbance diurnal variations affecting the P.M. hemisphere more than the A.M. and polar regions more than equatorial or temperate. Quiet magnetic conditions correspond to the absence from the earth's neighbourhood of certain solar emissions, which, arising from locally disturbed solar areas, and being projected into space along confined streams, produce magnetic disturbance when they come into proximity with the earth. Disturbance phenomena are due to additional magnetic fields intermittently superposed upon the earth's permanent field and upon the field responsible for the regular diurnal variations. Disturbance effects are experienced with special intensity or frequency over particular regions of the earth, relative to the earth's axes and the geocentric coordinates of the sun. The regular diurnal magnetic variations are of definite type, quite different from that of the disturbance diurnal variations; they depend as to type upon locality and season. The intensity of the changes proceeding at any station at any hour, so far as concerns these regular diurnal variations, is controlled by a solar agency different from that responsible for magnetic storms. This agency varies gradually in intensity throughout the solar cycle, and is connected with the general state of the sun rather than with localised outbreaks of activity. Its terrestrial magnetic effect is almost wholly confined to the day hemisphere of the earth, being greatest at any time over the regions immediately "beneath" the sun. Its influence diminishes rapidly with increasing zenith distance towards the twilight circle. These two solar agencies, the "disturbance" and the "general" must be quite different in character. The author discusses various suggestions as to the mechanism and inclines to the conclusion that the "disturbance" agent consists of electrical corpuscles, and the "general" agent of ultra-violet light. These agents, he considers, affect different layers of the earth's atmosphere, the disturbance layer being the aurora stratum, at a minimum height of 90 km. The diurnal variation layer must therefore lie below this limit and above the stratosphere.

In a further note, the author mentions that the lunar diurnal magnetic variation, unlike the solar, varies in amplitude according to the magnetic disturbance at the time, but full discussion of this is postponed.

W. W. B.

626. *Magnetic Character Figures for Kew Observatory*, May 23–30, 1919. **C. Chree.** (Terrest. Magnetism, 24. pp. 169–170, Dec., 1919.)—Describes how the "character" figures are arrived at in dealing with the Kew magnetograms. These figures are based almost entirely on the disturbance shown in D and H, little weight being attached to V. D and H are separately classified for each day, being assigned to one of nine classes according to the degree of disturbance. Consideration of the class number assigned to D and of that assigned to H for each day with, where necessary, further reference to the original curves leads to the classification of the day as "0," "1" or "2." The character figures for the days May 23–30, 1919, covering the time of the solar eclipse of that month, are set out. J. S. Di.

627. *Magnetic Storm of August* 11–12, 1919. **D. L. Hazard.** (Terrest. Magnetism, 24. pp. 171–173, Dec., 1919.)—The features of the magnetic storm of Aug. 11–12, 1919, as recorded by the observatories at Cheltenham, Porto Rico, Tucson, and Sitka of the U.S. Coast and Geodetic Survey, are briefly discussed. The storm began at 6h. 57m. G.M.T. on Aug. 11 and ended abruptly at 19h. on the following day. The salient points are tabulated. J. S. Di.

628. *Magnetic Storm, Aug.* 11–12, 1919. **J. Evershed.** (Nature, 104. p. 436, Jan. 1, 1920.)—Comparison of the times of sudden commencement of this storm at Kodaikanal and Eskdalemuir indicates an exact agreement suggesting that the impulse struck the whole earth simultaneously. Otherwise, as the sun was near the zenith at Kodaikanal at the time, the author thinks the effect might have been expected there rather sooner than in Great Britain. **C. Chree.** (Nature, 104. p. 468, Jan. 8, 1920).—Chree deals with the point raised by Evershed as to the simultaneity of sudden commencements of magnetic storms, and gives his reasons for concluding that any difference between stations is probably a matter of seconds only, and is less than the uncertainty of the time

of a sudden commencement. But he points out that the type of these storms varies from place to place; being principally marked in H in India, while in all three elements equally in the Antarctic, besides being as a rule in one direction only in India, but oscillatory at Kew and in the Antarctic. He considers that the type of a storm in the Antarctic differs according to whether it takes place by day or by night. He compares the amplitudes of the two types at Eskdalemuir and in the Antarctic, obtaining practically the same ratio for each—though the accordance may be accidental as the range is large for individual cases.

W. W. B.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

629. *Protected Screening Stand and Cardiographic Apparatus.* **R. Knox.** (Röntgen Soc., J. 16. p. 17; Disc., 17–18, Jan., 1920.)—The present apparatus is a protected screening stand, built essentially from the point of view of protection, but also from the point of view of technique, especially in relation to the heart, so that a permanent record may be obtained of the heart measurements. The upright screening stand incorporates a protective screening device and runs on rails so that it can be taken any distance up to 8 ft. from the antikathode. It has a movable part in the middle to permit adjustment to the height of the patient. Between this point and the back of the screen another diaphragm is generally placed so that the field of radiation just covers the screen used in examining the patient. The diaphragm is simply suspended in front of the tube box. The upright carries three moving parts and there are certain rods which are movable up and down. The object of these rods is to obtain a landmark so that a permanent record of the plate in relation to these points can be obtained, and the position registered, so as to be capable of reproduction at any time. This is an adaptation of the work of Vesneq and Bordet, who introduced a method of recording the enlargement of the heart. The edge of the heart shadow can be obtained quite well in the ordinary way, but no idea is given as to the depth. In order to overcome this difficulty the French workers introduced the method of bringing a wire down to the indication as given in one position, then by shifting the tube a distance of 10 cm. and by bringing into play another wire they obtained an index of the enlargement. The apparatus can be adjusted readily to the front of the chest wall, and to facilitate this the frame moves on wheels. An addition has been made in the shape of a frame fitting in front of the fluorescent screen so as to carry a sheet of paper. On this paper, which is transparent to the rays when put in front of the glass, the image can be seen, and the heart readily traced in outline, its index registered, and the whole thing recorded. It is hoped before long to have an adaptation of the moving method to this machine by which means it may be possible to corroborate very substantially the recording of the electro-cardiograph.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

630. *On the Lattice Theory of Zinc Blende.* **M. Born** and **E. Bormann.** (Deutsch. Phys. Gesell., Verh. 21. pp. 733–741, Dec. 5, 1919.)—For solving the problem as to whether the cohesion forces in crystals of heteropolar constituents may be regarded as electrical attractions of ions [see Abs. 528 (1919)], zinc blende is a specially suitable substance on the following grounds :—(1) Like the earlier investigated binary halogen salts of the type NaCl it is diatomic and crystallises in the regular system, while its lattice is different from that of NaCl, so that the formulæ for the physical constants are quite different from the NaCl type of lattice ; in consequence support to the theory would be of great significance. (2) According to electrolytic behaviour the ions Zn and S are diatomic ; these facts must also be ratified on the electrical cohesion theory and from the values of the crystal constants. (3) The crystal possesses a polar axis and is piezoelectric ; it is therefore very suitable for affording information as to whether by a deformation the atoms essentially function as point-forming force centres, or whether they themselves experience rotations and deformations. (4) The constants of elasticity, piezoelectricity, and the long-wave ultra-red special frequency, which can be calculated from potential expressions, have also been measured. (5) If the electrostatic interpretation of the repulsion exponent n is correct [see Abs. 530 (1919)], then with zinc blende a lower value of n must be given than for salts of type NaCl (where $n=9$), since the atoms possess lower symmetry. The determination of n will lead therefore to an insight into the symmetry relationship of the atoms. The author proceeds to to examine the problem given under heading (3) above. He finds from the formula, $z=\frac{2\pi C}{F}\cdot\frac{C_{14}}{\gamma}\sqrt{\frac{\mu_1\mu_2}{\varrho(c_{12}-c_{44})}}$, where z is the number of electrical quanta of the ion, c the velocity of light, F the Faraday constant, μ_1 and μ_2 the atomic weights, and ϱ the density, that $z=0\cdot 3$ for zinc blende, while electrolytic behaviour gives $z=2$. In consequence this apparent contradiction has to be investigated. Although the value of z appears to be 7 times too small, it is nevertheless of the correct order of dimensions, which points to the fundamental basis of the theory being correct. The paper, which is mostly mathematical, shows that the interaction of two electronic systems is not only a function of their distance apart, but also of the orientations, and attractions as well as repulsions have to be taken into account. The author concludes that the assumption of electrostatic cohesion together with a central force of exponent $n=5$, gives a close and correct approximation to exact theory. H. H. Ho.

631. *Melting-Points of the Lead Isotopes.* **M. Lembert.** (Zeits. Elektrochem. 26. pp. 59–60, Feb. 1, 1920.)—Starting from the Rutherford-Bohr atom Lindemann and Fajans had come to different conclusions as to the frequency of the atomic vibrations in the solid state. If $\nu=\sqrt{(f/m)}\ 1/2\pi$, where f indicates the directive forces on the atom, f should be proportional to m (Lindemann), or ν inversely proportional to $\sqrt{m}$. The recent determinations of the melting-points of the lead isotopes by Richards, Lembert, and Hall show differences of 0·06 and 0·01 deg. only, where Lindemann expected differences of 2·6 and 0·4 deg. The view of Fajans is thus confirmed, and Lindemann is said to have accepted it [Abs. 1244 (1919)]. H. B.

632. *Chemical Reactions caused by Radium Emanation.* **E. Wourtzel.** (Le Radium, 11. pp. 289–298, Sept.–Oct., and pp. 332–347, Nov.–Dec., 1919.)—After a review of the work on the subject the author describes his experiments, made in the Curie Laboratory, by mixing the respective gas directly with the emanation in glass bulbs of 40 cm.^{3}, wall-thickness 2·5 mm. (to resist pressures of 2 atmos. at a temperature sometimes above 300°), connected with the glass apparatus by capillary tubes. Analyses are conducted by condensing the gases so far as possible with the aid of liquid air; this condensation did not cause a loss of emanation in the case of H_2S, N_2O, CO_2, but did cause a slight loss in the case of the fourth gas studied, NH_3. Measurements are taken at intervals of at least 15 hours. The effect increases with increasing recipient volume. In the case of H_2S and NH_3 the compound is simply split up into H_2+S and $N+H_3$; the rate of decomposition of H_2S is independent of temperature between $-180°$ and $+18°$ and decreases very slightly as the temperature further rises to 220°. In the case of ammonia the reaction velocity, if equal to 1 at 18°, rises to 2·9 at 220° and increases slowly afterwards, being 5·19 at 315°. The nitrous oxide N_2O seems to undergo two decompositions, into N_2+O (this being the predominant reaction) and into $NO+N$; the presence of NO retards the reaction; the temperature coefficient of the reaction is small and negative between $-78°$ and $+18°$, then small and positive. The decomposition of CO_2 is analogous to that of water vapour, but very slow; it is accelerated by the presence of mercury, which would account for the unconfirmed observations of Ramsay and Cameron. A theoretical discussion of the results is reserved; it is pointed out, however, that the law of Faraday does not apply, the ratio M/N being too great in cases where there is no catalytic action (M being the number of molecules decomposed per Curie-second, and N the number of pairs of ions), and that the radio-chemical decomposition is principally due to the α-rays. H. B.

633. *British Chemical Standards Steel Analysis.* (Chem. News, 120. p. 7, Jan. 2, 1920.)—Analyses of turnings of 8 carbon steels, comprising one nickel steel, made at the Royal Arsenal, Woolwich. H. B.

634. *Micrography of Aluminium and Its Alloys.* **D. Hanson** and **S. L. Archbutt.** (Inst. of Metals, J. 21. pp. 291–304; Disc. and Corres., 305–318, 1919. Engineering, 107. pp. 450–453, April 4, 1919.)—The preparation and polishing of Al and its alloys should be carried out with great care because of the ease with which their structures become deformed. Such deformation not only leads to incorrect interpretation of the structures, but also creates difficulties in etching owing to tarnishing, which effectively hides the underlying structure and is very difficult to remove except by repolishing. In order to prevent entanglement of particles of emery in the surface of the specimen the emery papers are soaked in paraffin before use. Final polishing is effected by means of magnesia powder. The most suitable reagents for developing the crystalline structure of pure Al are 20 % aqueous caustic soda and

aqueous hydrofluoric acid between 10 and 20 % in strength, according to the coarseness of the structure. Iron exists as the compound $FeAl_3$ which is practically insoluble in solid Al. Being very hard it takes a very high polish, is whiter that Al and is easily detected without etching. Silicon forms a simple eutectiferous series with Al, the eutectic containing 10·5 % Si and melting at 570° C. Separately, $FeAl_3$ and Si are not easily distinguished from each other, but when seen together in an unetched specimen the Si appears as the darker of the two constituents. Silicon is practically unaffected by etching reagents, while the iron compound is darkened by caustic soda and dilute hydrofluoric acid. $CuAl_2$ is best distinguished from $FeAl_3$ by etching for two or three seconds in 20 % aqueous nitric acid, when the copper compound is coloured dark brown, leaving practically the whole of the other constituents unaffected. In all commercial alloys, zinc occurs as a solid solution. Etching of these alloys is best carried out in 20 % caustic soda solution, the thin black deposit produced being removed by immersion in a solution of chromic acid. The zinc-rich portions of the solid solution are the first to become covered with this black deposit, so that in the examination of castings useful information on the cored structure can be obtained by light etching in caustic soda without treatment in chromic acid. Nickel forms the compound $NiAl_3$ which is very similar to $FeAl_3$. Alone, it is stained more rapidly than the iron compound but when the two occur together they are very difficult to distinguish from each other. Alcoholic nitric acid, containing from 1 to 10 % of the acid, is the best reagent for etching alloys of Al with Mg. Manganese forms the compound $MnAl_3$ which crystallises in well-defined cubes unattacked by any etching reagent. F. C. A. H. L.

635. *Zirconia: Industrial Development.* **E. Coley.** (Chem. News, 120. pp. 7–8; Disc., 8, Jan. 2, 1920. Paper read before the Birmingham Metallurgical Soc., Dec., 1919.)—There is no evidence that zirconia carbides form below the fusion point, but zirconia has the curious property of absorbing carbon from reducing atmospheres (CO) and turning black; the colour can be removed by oxidising heating. The zirconia material can be shaped *in situ*, though there is liability to warping. In reply to questions, **Ramsden** stated that zirconia did not cost twice as much as other refractories, and lasted from 4 to 10 times as long; a zirconia cement could be applied in the wet. Spraying zirconia preparations on fire-bricks was not effective. H. B.

636. *Synthetic Cast-Iron.* **C. A. Keller.** (Iron and Steel Inst., J. 100. pp. 139–157; Disc., p. 158, 1919. Engineering, 108. pp. 632–634, Nov. 7, 1919.)—The term "synthetic" cast-iron is used to denote the carburised product obtained by melting steel turnings with carbon in the electric furnace. Basic slag is also added to reduce the conductivity of the charge and also to carry on a desulphurisation. With steel turnings containing 0·44% Si, 0·55% Mn, and 0·07% S, a white-iron was produced of the following composition: C, 3·55%; Si, 0·52%; Mn, 0·48%; S, traces. By introducing more SiO_2 in the charges an iron higher in silicon can be produced. Small coke or wood charcoal of approximately the same size as the turnings are excellent carburising agents. In a furnace producing 80–100 tons of this pig-iron per 24 hours, the electrical consumption is 675 kw.-hours per ton, the electrode con-

sumption may be as low as 6 kg. per ton, and about 80 kg. good coke are required. The labour required for a furnace producing 100 tons per day is 15 men on the furnace, 7 on the pit, and 2 in the stock yard. The casts are preferably taken to a mixer before use. Excellent material for the manufacture of malleable cast-iron is produced. If the material is phosphoric a preliminary treatment under basic slag is required. The process and plant are described in detail. F. C. T.

637. *Forgeability of Iron-Nickel Alloys.* **T. D. Yensen.** (Am. Inst. Mining Eng., Bull. No. 157 [12 pp.], Jan., 1920.)—Gives the results of investigations on the forgeability of iron-nickel alloys and shows that pure Fe-Ni alloys do not forge readily, if at all, at ordinary forging temperatures. The addition of Al, carbon, Mg, or Si, has little or no effect on the forgeability. Manganese or titanium in amounts equal to 2 % of the nickel or iron, whichever is present in the lower percentage, makes the alloys forgeable. The degree of forgeability of a material depends on the relative strength of the crystalline and the intercrystalline, or amorphous, material, and the fact that Mn and Ti transform iron-nickel alloys from non-forgeable to forgeable alloys, means that these elements have the ability to strengthen the amorphous material to such an extent as to make it stronger than the crystalline material. C. O. B.

638. *Relationship of Physical and Chemical Properties of Copper.* **F. L. Antisell.** (Am. Inst. Mining Eng., Bull No. 157. [5 pp.], Jan., 1920.)—Deals with the "pitch" and "set" of refined copper, the influence of oxygen and sulphur on the physical properties, and the reasons for rejecting copper. The following analysis is given for good electrolytic copper: Copper, 99·95; silver, 0·001; oxygen, 0·039; sulphur, 0·003; arsenic, 0·0015; antimony, 0·002; nickel, 0·0015; iron, 0·002 %; lead and bismuth, nil; selenium and tellurium, trace. The electrical conductivity of copper is considered the most convenient test for its general properties; it varies in inverse ratio to its oxygen contents, and is directly proportional to the number of bends which is a function of its reduction in area. It is shown that as the tensile strength of copper increases, the conductivity decreases; as the oxygen contents increase the tensile strength increases and the resistance to bending decreases; as the tensile strength increases the elongation decreases. C. O. B.

639. *Intercrystalline Brittleness of Lead.* **H. S. Rawdon.** (Am. Inst. Mining Eng., Bull. No. 158. [16 pp.], Feb., 1920.)—A type of deterioration of lead sheathing is described in which the metal became weak, brittle, and capable of being crumbled easily. This deterioration occurs as a result of corrosion, the attack of the metal being localised along the crystal boundaries, the brittleness being truly intercrystalline. Practically all the commonly occurring impurities in lead are insoluble in the solid metal and are found between the crystals. The intercrystalline brittleness is due largely to the behaviour of these impurities when the metal is immersed in an electrolyte. No evidence of the existence of an allotropic form of lead was obtained and the forms previously described as allotropic modifications of lead appear to be due to an intercrystalline attack by the electrolyte, immersion in which was necessary to bring about the allotropic change. C. O. B.

640. *Note on the Determination of Chemical Constants.* **A. C. Egerton.** (Phil. Mag. 39. pp. 1–20, Jan., 1920.)—Up till recently, the value of the integration constant of the vapour-pressure formula, known as the "chemical constant," has generally been considered to be about 3 (in absolute units). From affinity measurements, however, hydrogen appeared to have a lower value, while other substances such as iodine had a higher value of about 4. The point arose whether the constant depended on the nature of the element, and Sackur and Tetrode developed an expression, $i = ln(2\pi m)^{3/2}\kappa^{5/2}/h^3$, wherein the constant is considered to be related to the atomic weight. Lindemann has also shown from dimensional considerations that the integration constant of a monatomic substance should be equal to a universal constant plus $1\frac{1}{2}$ times the log. of the atomic weight. It is of importance, therefore, to determine as accurately as possible the chemical constants of several monatomic elements. For this purpose a careful calculation of the chemical constant of mercury has been made and the vapour pressures of zinc and cadmium previously investigated [Abs. 142 (1917)] have been used to deduce their chemical constants and give additional support to the validity of the result, which latter is in close agreement with the above theoretical expression. Methods of calculating the chemical constant and the conditions necessary for obtaining accurate results are discussed. It is shown that the older formula by which most of the constants were calculated leads to a result without physical significance. The formula which should be used requires a knowledge of the specific heat of the substance (*i.e.*, of the value $\beta\nu$). *Mercury.* The chemical constant of Hg is calculated and the accuracy of the result is discussed. The constant is found to be $1\cdot820 \pm 0\cdot032$. This value leads to a value for C_0, the universal constant of the theoretical relation $-C_0 = C - 1\cdot5 \log M$, within the experimental error. The chemical constants C of *cadmium* and *zinc* are evaluated from the vapour-pressure measurements, and the values calculated using the theoretical value of C_0 are found to lie within the experimental error. The value of C_0 for monatomic substances, the mean of all values so far determined, is found to be $-1\cdot622$.

The latent heats of vaporisation of zinc, cadmium, and mercury are given for various temperatures, and the maximum value is found for all monatomic substances at a temperature $\beta\nu/T = 1\cdot95$. There appears to be need for further experiment before the data obtained by Langmuir and Mackay for the vapour pressures of tungsten, molybdenum, and platinum at high temperatures can be used for accurate determinations of their chemical constants. Stephan's constant for full radiation, σ, has been deduced from the mean value of the constant C_0 and is given as $5\cdot27 \times 10^{-2}$ erg cm.$^{-2}$ deg.$^{-4}$. This value appears to be definitely lower than the more recently determined values, within the experimental error, and is dependent only on the vapour pressure, specific heat of mercury, gas constant, and velocity of light. H. H. Ho.

641. *Affinity of the Halogen Atoms for Electrons.* **M. Born.** (Deutsch. Phys. Gesell., Verh. 21. pp. 679–685, Dec. 5, 1919.)—Haber having objected that the author's views [Abs. 686 (1919)] would make the Cl-ions in KCl and in NaCl identical, the author points out that the ions may differ, and that the energy-difference corresponding to their non-identity would be a function of the distance between Cl-ion and metal ion. Atomistically the most important quantity which his theory admits

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of calculating is the work E to be done in order to pull an electron out of a halogen atom. This E is positive since the atom has an affinity for the electron which enables it to pass into the ionic state; the affinity is thus a kind of negative ionisation-pressure. Bohr's ring-electron model does not provide for the affinity, the determination of which would be desirable also with respect to the spectra. In the calculations use is made of U, the lattice energy; D, the heat of evaporation or sublimation of a metal or heat of dissociation of a diatomic halogen gas; J, the work of ionisation of a neutral metal atom, and the E mentioned. The heat of disruption of an element into free ions and electrons is $Z=D+J$ for metal atoms, and $Z=D-E$ for halogen atoms. He finds that the E for chlorine, bromine, and iodine are 5·16, 3·64, 3·33 volts, decreasing as the atomic weight increases. A direct method of determination is not known, but it can be deduced from the work J_{HCl} necessary for the ionisation of HCl into $H_{+}+Cl_{-}$. These J values for HCl, HBr, HI turn out to be practically of equal magnitude, 13·9, 13·5, 13·1 volts, and again nearly equal to $J_4=13 \cdot 4$ volts (310 kg. cals.); that signifies that the bonding between the H-nucleus and the halogen-ion is as strong as that between the H-nucleus and an electron of the neutral H_{-} atom. This throws new light on atomic and molecular structure. H. B.

642. *The Occlusion of Gases by Metals. General Discussion.* (Faraday Soc., Trans. 14. pp. 173–263, July, 1919.)—After an introductory address by **R. A. Hadfield,** papers were read, as contributions to the discussion, by **A. W. Porter, C. Johns, A. McCance, T. Baker,** and **J. H. Andrew.** For these and the accompanying discussion the original pages should be referred to. L. H. W.

643. *Electronic Affinity of Gases.* **K. Fajans.** (Deutsch. Phys. Gesell., Verh. 21. pp. 723–727, Dec. 5, 1919.)—In the pure rare gases and in nitrogen the electrons are free and highly mobile [Franck, Abs. 963 (1910)]. When small proportions of electro-negative gas elements are mixed with the gases, the mobility of the electrons then attached to mass particles is reduced; from the life periods of these particles Franck proposed the ascending potential sequence N_2, H_2, O_2, NO, H_2O, Cl_2, the elements in this series beginning with oxygen to display a decided affinity for electrons. The question discussed is the nature of this affinity. From his study of the halogens the author concludes that the collision between a slow electron and a halogen molecule yields a negative atom-ion and a neutral atom, energy being liberated. The simultaneous collision of 2 electrons with 1 molecule gives 2 atom-ions. The affinity of the halogen atom for the electron is thus sufficiently large to loosen the bonds between the atoms in the molecule. The assumption that the halogen ions are atoms seems to contradict the observation of Franck and Pringsheim that, in the HCl flame, the negative ions are less mobile than the positive. The author would say that the anomaly lies, not in the slowness of the negative ions, but in the high speed of the positive ions, the carriers of the positive electricity being free hydrogen nuclei. H. B.

644. *Heat of Hydration of Gaseous Atomic Ions.* **K. Fajans.** (Deutsch. Phys. Gesell., Verh. 21. pp. 709–714, Dec. 5, 1919.)—In his previous papers [Abs. 162 and 272 (1920)], the author had overlooked the fact that the heat of formation of the ions, as calculated after Ostwald from the absolute potential and its temperature coefficient for the hydrogen-platinum electrode, does not apply to liberated electrons, because the electrons would remain within the Pt. From the hydration-heats thus obtained a deduction of about 100 cals. should hence be made for the heat of vaporisation of the electrons. This correction would not, however, affect the differences. It is further pointed out that the term "heat of hydration" is not to imply that the solution of an atomic ion in water would lead to the formation of definite hydrates; there will be a dielectric polarisation of the water molecules with respect to the ion; the ion at rest need not be a hydrate of definite composition.

H. B.

645. *Electronic Affinity of the Halogen Atoms and the Work of Ionisation of HCl, etc.* **K. Fajans.** (Deutsch. Phys. Gesell., Verh. 21. pp. 714–722, Dec. 5, 1919.)—A quantitative estimate of the energy-change involved in the transition of a halogen atom into the condition of a negative ion, and thus of the affinity of these atoms for electrons, may be made by starting, *e.g.*, from crystallised KCl. In two ways we may arrive at free K- and Cl-ions, at infinite distance apart: (1) by direct dissociation which requires 163 kg.-cals/mol; (2) let the salt be decomposed into the metal and Cl gas, and the metal vaporised and dissociated into K-ions and electrons, whilst the diatomic Cl_2 is split into Cl-atoms which are joined to the electrons split off the K; in these processes the work of ionisation of the Cl-atom is alone unknown. The results show that the union between the halogen atoms and electrons is spontaneous and accompanied by a considerable liberation of energy. This union should further lead to the emission of a radiation of wave-length 2440, 3350, 3490 for Cl, Br, I respectively; so far there is no spectroscopic confirmation. As regards the work of ionisation of HCl, HBr, HI, the calculation yields 322, 310, 300 kg. cals., or 14·0, 13·4, 13·0 volts, values decreasing with increasing atomic weight as in the case of the heat of hydration.

H. B.

646. *On the Equation of State for Arbitrary Temperatures and Volumes, Analogy with Planck's Formula.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1184–1199, 1919.)—In some previous papers [see Abs. 62 (1919)] the author has studied the dependence on temperature of the quantities *a* and *b* of van der Waals' equation on the ground of kinetic considerations. The conclusion drawn was that the quantity *a* must steadily increase with descending temperature to a max. value in the neighbourhood of the abs. zero point, after which it again decreases to the value 0 at $T=0$. All this holds for very large volumes. With respect to *b* similar computations were made, but the mathematical difficulties became greater and greater, and the results were very complicated. For small volumes this treatment was still less suitable. The author now adopts another standpoint by substituting for the three-dimensional problem an analogous problem of one dimension, and then transforms the result to one which will hold for three dimensions. By so doing, the nature of the sought dependence on the temperature and the volume of the constants occurring in the equation of state will not be modified. This method has the advantage of application to small volumes, and results are therefore obtained which are universally valid

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not only for arbitrary temperatures, but also for arbitrary volumes, from $v=a$ to $v=b$. The relation between the mean energy and the temperature was found to be the same for small volumes and low temperatures as the relation $E=E_0+2E_0/(C^{2E_0/RT}-1)$, which was drawn up by Planck on behalf of the theory of radiation on assumption of the quanta hypothesis, in which only $\frac{1}{2}Nh\nu$ would have to be substituted for E_0 to give Planck's expression. By a purely kinetic way, on the sole foundation of the ordinary laws of classical mechanics, Planck's expression can therefore be derived.

Section 2 of the paper deals with general considerations on the nature of attractive and repulsive forces. In Section 3 the fundamental equations are constructed. Sections 4, 5, and 6 deal with special calculations and with the important limiting cases at high and low temperatures respectively. H. H. Ho.

647. *Determination of the Rate of Solution of Atmospheric Nitrogen and Oxygen by Water.* II. **W. E. Adeney** and **H. G. Becker**. (Roy. Dublin Soc., Proc. 15. pp. 609–628, Sept., 1919.)—The authors have continued experiments [Abs. 1202 (1918)] on the above subject with the object of reducing the observations to unit area and volume. They derive equations which give for oxygen, nitrogen, and air the amount of gas dissolved at the end of any given time and at any temperature starting with any degree of saturation with the gas. The equations can also be used to calculate curves showing the rate of solution in water of the different gases under different conditions. A. F.

648. *Impact Ionisation and Work of Dissociation of Neutral Molecules.* **J. Franck, P. Knipping,** and **T[hea] Krüger**. (Deutsch. Phys. Gesell., Verh. 21. pp. 728–732, Dec. 5, 1919.)—Bohr's hydrogen molecule should not be stable after losing one electron, and a positive H_2 ion should not exist, but the ionisation should accord to $J_{H_2}=Q_{H_2}+J_4$, where the J are the ionisation potentials of the molecule and the atom, and Q_{H_2} is the work of dissociation per molecule. Now $J_4=13\cdot5$ volts (from the series spectrum), $Q_{H_2}=60{,}000$ cals. (from the Bohr-Debye model)$=2\cdot6$ volts, and ionisation should begin at $13\cdot5$ volts$+2\cdot6$ volts$=16\cdot1$ volts. But the molecule-model cannot have the assumed structure; for H_2 should then be paramagnetic (not diamagnetic), the observed Q values range from 87,000 to 100,000 cals., and J. J. Thomson has actually observed the H_{2+} ion. There is, further, evidence of two stages in the ionisation, at 11 and at 15·8 volts, and photoelectrically of an ultra-violet radiation at 13·6 volts. The authors hence re-determined the ionisation stages, paying special attention to any contact potentials; the method is later to be described. They find, in addition to their former values of 11·5 and 13·6 volts, a strong ionisation at 17·1 volts, and a new stage at 30·4 volts. The first of these stages marks (as in monatomic gases) the resonance potential at which light excitation of the atom sets in; the energy is transferred by the striking electron which sends an electron of the atom into the quantum-orbit further out. The ionisation potential corresponds to the excitation of the ultra-violet frequency of the absorption series; in the case of the hydrogen atom the two values would be 10·1 and 13·5 volts. When the electrons hit molecules, there must be splitting into atoms, since atomic frequencies are excited. The work of dissociation should then mark the stages: (1) 10·1 volts+Q, separation of the atoms into a normal atom and into a double-quantum atom

emitting the first line of the Lyman series; (2) 13·5+Q, separation of atoms into a normal atom and a positive ion, as well as an electron, *i.e.*, ionisation; (3) 2×13·5 volts+Q, separation of atoms into 2 positive ions and 2 electrons, *i.e.*, an intensified ionisation; other separations would be possible. Q seems, from the experiments, to have the value 3·5 volts. Calculated in calories the work of dissociation would be (81,300 ±5700) cals. which would agree with Langmuir's figure 84,000. At 11 volts, ions would (Stark) be formed of larger diameter than at 17·1 and 30·4 volts; and these H_{2+} ions would be very stable.
H. B.

649. *Simple Hydrogen Electrode.* **C. H. Bailey.** (Am. Chem. Soc., J. 42. pp. 45–48, Jan., 1920.)—Details are given of a hydrogen electrode which is simple in construction and operation, has only a short distance between the platinised electrode and the point of contact with the potassium chloride solution in a standard electrode, and permits of complete immersion of the platinised electrode. Such electrodes have proved very useful in determining the hydrogen-ion concentration of water extracts of foods, such as wheat flour. T. S. P.

650. *Polarisation Tensions of Iron in Solutions of its Complex Salts. Relations between these Tensions and the Dissimulation of Analytical Characters of Ferric Ions.* **N. R. Dhar** and **G. Urbain.** (Comptes Rendus, 169. pp. 1395–1397, Dec. 29, 1919.)—The electrolytic cell consists of two half-elements joined by a solution of potassium chloride. One half-element consists of a metallic electrode in a solution of one of its salts, and the other is an electrode of mercury in a solution of calomel and potassium chloride. The polarisation tension is defined as the difference between the e.m.f. of the whole cell and the corresponding value as found in Auerbach's results for the half-element containing the mercury electrode. The tension should depend on the number of free metallic ions in the solution, the tension diminishing as the number of ions increases. These measurements should, therefore, in the case of complex salts, give an indication as to how far the metallic constituent of the complex is dissimulated. The results obtained with simple and complex iron salts are in agreement with those obtained by Pascal as to their magnetic susceptibilities. T. S. P.

651. *Polarisation in Solutions of Iron.* **W. A. Noyes, Jr.** (Comptes Rendus, 170. pp. 177–180, Jan. 19, 1920.)—Nernst's formula $A=0\cdot002I/m_1n_1$, for calculating the value of A in the equation $E_p=A\log_{10}I+B$, which gives the potential of an electrode traversed by a current, does not apply to the polarisation of solutions of ferrous salts, although it gives values proportional to the experimental values. T. S. P.

652. *Transport Number of the Ions of Cadmium Iodide.* **G. Heym.** (Ann. de Physique, 12. pp. 443–455, Nov.–Dec., 1919.)—From a series of measurements it is shown that the transport number of iodine ions varies from 0·55 to 1·0 for solutions of cadmium iodide in which the concentration varies from 0·007 to 0·07 gm. of iodine per litre.
T. S. P.